QUESTIONS AND ANSWERS ON AUTOMOBILE TROUBLE TRACING

Newnes "Q and A" Manuals

QUESTIONS AND ANSWERS ON AUTOMOBILE TROUBLE TRACING

EDITED BY
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With 59 illustrations
and Engine Trouble Tracing Chart

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PREFACE

THIS book has been specially compiled to provide the service mechanic and the mechanically-minded owner or operator with a sound and practical guide to the tracing and elimination of the faults most likely to be encountered in the running, inspection, maintenance, and repair of modern automobiles.

The ability to diagnose and locate faults rapidly is a prime requisite of successful and profitable servicing. The information—presented in the form of question and answer—has been carefully selected to assist in the speedy tracing of faults by deduction from their symptoms, or by simple tests designed to distinguish between efficient and defective components. Most of the tests described do not require the use of elaborate test gear and analysers.

This book will it is hoped be found of real use to all who wish to improve their ability to locate the cause of any fault likely to be encountered.

More detailed information on the overhaul and repair of Engines, Brakes, and Transmission and Steering will be found in the companion volumes in the Series.

E. MOLLOY

CONTENTS

SECTION		PAGE
1.	Engine Faults	1
2.	Carburettors	19
3.	Fuel Pumps	36
4.	Cooling and Lubrication	42
5.	Ignition	49
6.	Batteries, Dynamos and Starter Motors	62
7.	Transmission Gear	85
8.	Brakes	99
9.	Steering and Tyres	113
10.	Lighting and Accessories	125
11.	Wiring Faults	135
12.	Bodywork	142
13.	Engine Trouble Tracing Chart ..	146
	Index	150

Section 1

ENGINE FAULTS

When tracing faults why is it necessary to take into account the particular make or model concerned ?

Some designs possess inherent defects which do not become noticeable until after a certain mileage has been reached. Although such models are usually modified subsequently, much time may be saved when dealing with the original vehicles by a study of the manufacturers' service manuals for details of characteristic faults.

What test equipment is required to carry out a thorough test of the condition of a vehicle engine ?

(1) A vacuum gauge, for checking engine mechanical condition and cylinder balance; for verifying condition of ignition and carburation, and for checking and resetting ignition timing and carburettor adjustment.

(2) A voltmeter, for checking the ignition system, contact-breaker points, and for making electrical tests, etc.

(3) An ammeter, for checking battery consumption, ignition-coil consumption, and for making electrical tests.

(4) A sparkmeter, for checking ignition high-tension system, and testing and adjusting sparking plugs.

What are the three main classes into which failure to start can be divided ?

(1) Bad cold starting, bad hot starting.
(2) Refusal to start with the engine cold.
(3) Refusal to start with the engine hot.

What are the most likely causes of bad starting with the engine either hot or cold ?

The following faults are most likely to cause bad starting under both conditions: seized rocker-arm, complete absence of spark, inlet valve stuck open, incorrect throttle opening, no fuel, excess of fuel due to abuse of the strangler valve (this is less likely to cause trouble with a cold engine than with a hot engine), the strangler valve stuck in a closed position, excessive air leaks in the induction system, battery charge too low to drive starter motor and to supply ignition coil at the same time, general failure of the ignition system, spark plug gaps set too wide for the particular type of ignition coil, timing chain slipped, leads from the distributor to the spark plugs accidentally or maliciously changed, badly sooted plugs.

What additional faults could cause cold-starting troubles ?

These include: low-grade fuel, moisture on the insulator surfaces of the spark plugs, strangler valve not closing fully, unsuitable grade of oil, condensation inside the distributor, failure of the easy-starting device, unsuitable plugs or plugs which are badly pocketed in the cylinder head.

What faults are peculiar to hot-starting difficulties ?

Apart from faults already mentioned, there are: overheating of the float chamber on down-draught type carburettors, this causing the fuel to boil over into the induction pipe, which it fills with a mixture too rich to

fire. Where this is suspected, or where the strangler valve or other starting device has been used, open the throttle wide and turn the engine over a few times to clear out the cylinder head and induction pipe. If a hot engine will not start without the use of the strangler valve, bad air leaks in the induction system or through the inlet valve guides should be suspected.

How would you investigate a sudden stoppage where there is no backfiring through the carburettor ?

This is almost invariably an ignition fault, and the search can be limited to discovering whether or not the entire electrical system is dead, i.e. lamps, starter motor, horn, etc. If this be so, particular attention should be paid to the battery, main leads, and earth connection. Where the fault appears to be confined to the ignition system, the fault is generally located in the battery connection to the coil, the switch, the distributor, or the condenser, or in any of the various intermediate connections. The fault may take the form of a disconnected lead, broken lead, or short-circuit.

What faults would you look for in the case of a sudden stoppage accompanied by backfiring through the carburettor ?

This is an indication that the fault is a lack of fuel: possible contributory causes include an inlet valve stuck open, a broken inlet-valve spring, a bad fracture of the induction pipe or carburettor, acute pre-ignition, ignition timing or valve timing slipped. The last three faults, however, are accompanied by explosions in the exhaust pipe.

In the case of an engine stoppage on the road, how would you (a) Test for petrol supply; (b) Make a mechanical test ?

(*a*) First make sure that there is petrol in the tank. Then if there is petrol in the tank but none in the

carburettor, investigate each section of the fuel supply system in turn, bearing in mind faults such as: petrol pipes may be blocked, possible stoppage in the petrol tank outlet, or petrol filter, petrol pump or vacuum feed mechanism out of order.

(*b*) Mechanical test. If petrol is reaching the carburettor, it is recommended that a test should be made for mechanical faults. Turn the engine over by means of the starting handle, noting whether the compression is good on each cylinder: this will immediately bring to light trouble in the crankcase, or with the valve mechanism. For example, a broken valve-spring, a stuck valve, or a broken connecting rod will each produce poor compression in one cylinder, and can be quickly located by this test.

What are the chief causes of engine knocking ?

(1) Badly carboned cylinder head and pistons. This is really caused by pre-ignition, and is not affected much by retarding the ignition lever.

(2) Ignition too far advanced. This also causes the charge to be ignited before the piston has reached the top of its stroke. This can easily be remedied by retarding the ignition lever. It is therefore a simple matter to distinguish between this fault and that mentioned above.

(3) Badly worn cylinders or pistons. This form of knocking usually disappears when the speed of a car is increased beyond about 20 m.p.h. Retarding the spark will also cause this particular form of knocking to disappear.

(4) Wear in the engine bearings, i.e. the big end or the little end of the connecting rod and the crankshaft bearings. This type of knock can usually be located as coming from either the exhaust or induction pipe, or from the crankcase. It occurs at all speeds. In addition to the above, undue noise from the engine may be caused by excessive valve tappet clearance, or by a slack chain in the timing case.

Why do unequal tappet clearances, especially of the exhaust valves, affect idling ?

An alteration in tappet clearance alters the exact time of opening and closing of the valve, this in turn altering the quantity of burnt gas that always remains in the cylinder head at the end of the scavenging stroke. This burnt gas affects the idling mixture, and if of different amounts in various cylinders gives erratic idling.

How may pinking be recognised ?

Pinking produces a characteristic metallic ringing noise and usually occurs when the engine is heavily loaded or is accelerating. This noise may also arise from overheating.

What faults tend to produce pinking ?

(1) Ignition timing too far advanced.
(2) Faulty automatic advance mechanism.
(3) Excessive carbon in the combustion chamber.
(4) Unsuitable fuel.
(5) Mixture too weak.
(6) Overheated valves (incorrect seating, insufficient clearances, unsuitable material, etc.).

What are the signs that decarbonising is necessary ?

The usual indication is the development of roughness in the running of the engine, often accompanied by "pinking". It should be noted, however, that with some anti-knock fuels, pinking may not occur and in these cases the only indication is rough running, general sluggishness, and a tendency to overheat.

What are the symptoms indicating that valve grinding is necessary ?

These are generally somewhat similar to those for decarbonising, namely, rough running, loss of power, and

poor acceleration; all of these symptoms being basically due to loss of compression. Faulty functioning of the valves also results in there being excessive consumption of petrol.

What is the most probable cause of "backfires" or explosion in the silencer?

Valve trouble. A sticking inlet valve or a weak or broken valve spring will cause "spitting back" in the carburettor. A sticking exhaust valve or damaged spring will cause explosions in the silencer.

Describe another possible cause of valve trouble.

Another, though rare, cause of valve trouble is gumminess. This is generally the result of using impure fuel, and sometimes, to a certain extent, of upper-cylinder lubricant. Such gumminess can usually be detected when the valves are taken down, and the attention of the owner should be drawn to the fact to prevent recurrence of the trouble.

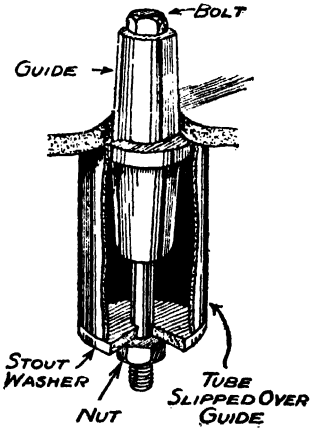


FIG. 1.—METHOD OF REMOVING WORN VALVE GUIDE.

The new guide can be drawn in reversing the tube and washer.

What would you look for when examining valves ?

When the valves have been withdrawn from the engine, look for the following faults: burning of the valve seating, distortion of the valve head, wear of the stem, and pitting of the seating.

What is the best treatment for a badly burnt valve ?

Scrap it and obtain a new valve. Any attempt to grind in burnt valves will usually lead to extensive and unnecessary damage to the valve seating.

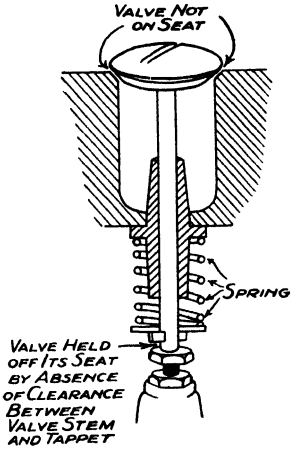


FIG. 2.—BEFORE GRINDING IN A VALVE MAKE SURE THAT THE TAPPET IS NOT HOLDING THE VALVE OFF ITS SEAT.

How would you deal with pitted valves ?

If the faces of the valves show signs of heavy pitting (i.e. carbon-filled depressions on the working faces), it is advisable to true them up with an electrical grinding machine or, if this is not available, with a hand refacing tool, though this will require considerable care in selection and use.

How can the layer of hard scale be removed from valve seatings ?

Before hand grinding the valves, this scale, which is likely to prove too hard for the normal cutting tool, should be removed. This may be done by any of the following three methods: (1) by the careful use of a

fine-cut file; (2) by grinding it lightly on an emery wheel, rotating it continuously so as to avoid the formation of flats; (3) by means of a lathe, using a fine-cut file.

What is the best treatment for a badly damaged valve seat ?

Recut the seat and grind in a new valve. If the damage is extensive it may be necessary to rebore the seat and use a slightly larger valve. The latest method is to rebore the valve port and fit a liner or bush to form a new valve seating of the correct size.

How can you tell when a valve has been correctly ground in ?

Examination of its face should show an even matt surface all the way round, while the seating should have a perfectly even grey surface. If there are any traces of bad surfaces remaining, apply a fresh supply of paste and repeat the operation until both the valve and the seating are free of irregularities.

Finally, an exacting test may be made by marking the valve face radially, at intervals, with a pencil; then dropping the valve on to its seat and, with the valve grinding tool, turning it very slightly (approx. $\frac{1}{8}$ in.). If all the pencil marks are erased, this will indicate that the seating is satisfactory but if some marks remain, further attention is required.

What are the troubles caused by incorrect tappet clearances ?

Loss of compression is often caused by faulty setting of the tappets. Some owners, hoping to lessen engine noise, reduce valve clearance to a minimum: then when the engine is driven hard, the clearances are insufficient and the engine overheats.

For this reason it is better to err on the side of too large rather than too close a setting. The modern

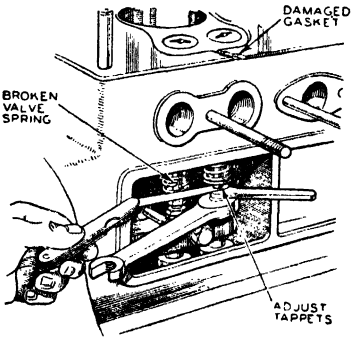


FIG. 3.—METHOD OF ADJUSTING TAPPET.
Two faults which must be watched for are also shown.

tendency is to use large clearances, of the order of 0·02 in. with the engine cold, together with special camshafts designed to reduce the engine noise.

How would you identify noisy valve rockers or tappets ?

Since valve rockers are controlled by the camshaft, which revolves at twice the speed of the crankshaft, noises from this source will be audible at much lower engine speeds than those from components whose movement depends upon the crankshaft. In addition, valve rocker noise can be recognised by its characteristic clicking sound that increases in intensity with rising engine speeds.

What may cause valve rocker noise ?

This is usually the result of excessive tappet clearances, either due to faulty adjustment or to wear of the cams and tappet faces.

Rough or worn rocker ball pins and push rod cups may also give rise to noise.

How can the correct compression pressure of an engine be calculated ?

The compression pressure should be equal to atmospheric pressure multiplied by the compression ratio of the engine concerned, plus atmospheric pressure.

What is the relationship between atmospheric pressure and altitude ?

The atmospheric pressure decreases with an increase in height, according approximately to the following table:

Altitude	*Atmospheric Pressure* (*lb./sq. in.*)
Sea-level	14·7
1,000 ft.	14·1
2,000 ft.	13·6
3,000 ft.	13·1

What faults may be indicated as a result of a compression test ?

A high compression pressure may be the result of excessive carbon deposit.

Where there is low pressure in one or more cylinders, a further test should be carried out after injecting a small quantity of engine oil through the sparking plug aperture so as to form a seal around the piston rings. If the second test then shows an increase of pressure it is most likely that the piston rings require attention; if there is no increase in pressure, this would suggest that the valves are faulty.

Equal low pressure in two adjacent cylinders may indicate that there is a leakage between them, usually caused by a faulty cylinder head gasket or damage to the block or head face.

What does the presence of water in a cylinder bore coupled with low water level in the radiator indicate ?

A cylinder head gasket blow to the water jacket. This can frequently be confirmed by listening at the radiator filler neck, or by the appearance of bubbles in the cooling water.

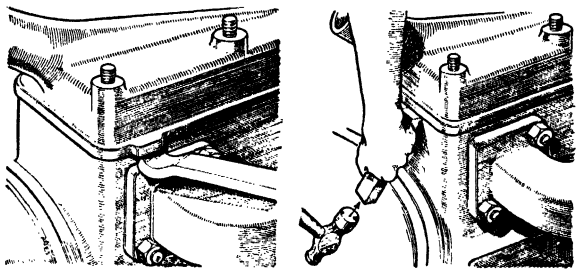


FIG. 4.—METHOD OF REMOVING CYLINDER HEAD.
(*a*) When lugs are provided.
(*b*) When no lugs are provided.

Describe a method of confirming suspected cylinder head gasket leakages.

Gasket leakages between the cylinder bore and the exterior of the block are often audible; and can be located by smearing engine oil on the suspected points, leakage being denoted by bubbles.

What are the usual symptoms of cylinder bore wear ?

The first indication is usually the loss of power, acceleration, and speed (due to loss of compression) together with excessive consumption of lubricating oil and petrol.

This may be rapidly followed by a general deterioration of the entire engine unit, particularly in respect of wear to all bearing surfaces on the crankshaft and connecting rods (not excluding the piston pins) so that an engine which is normally efficient and quiet in operation, becomes noisy: an almost certain indication that serious damage may result from failure to investigate the trouble.

What are the chief causes of cylinder wear ?

It should be recognised that cylinder wear commences from the first time that the engine is operated, and continues throughout the lifetime of the engine. Modern research is therefore directed always at discovering new alloys that will offer greater resistance to wear.

The most obvious cause of cylinder wear, beyond the normal, is lack of efficient lubrication between the cylinder walls and the piston or piston rings. In practice, however, this is unlikely to occur unless there is a failure of the oil pump or drive.

A primary cause of cylinder wear is the prolonged and injudicious use of the strangler valve on the carburettor. This is because starting the engine from cold destroys the oil film between the piston and cylinder wall, particularly where the air supply is strangled and the raw petrol washes away the oil film, thus allowing direct metallic contact between the piston and bore.

Describe some of the other causes of excessive cylinder wear.

(1) Chemical action set up by the products of combustion.
(2) Road dust or particles of burnt carbon being projected into the oil film.
(3) Excessive piston clearances causing "slap" and wear due to the impact on reversal of the reciprocating motion at the top of the stroke.
(4) The lapping effect of light-alloy pistons in conjunction with (2).
(5) Bent or twisted connecting rods.

(6) Misalignment of connecting rods in relation to cylinder bores.
(7) Misalignment of connecting rods in relation to the crankshaft.
(8) Misalignment of crankshaft due to worn bearings.
(9) Whip in crankshaft due partly to (8).
(10) Gudgeon pins too tight a fit.
(11) Oxidisation due to water percolating past a leaky cylinder head gasket.
(12) Excessive water circulation causing the engine to run too cool.
(13) Use of inferior cylinder material.
(14) Ring wear.

How can the chemical and corrosive effects be minimised ?

(1) Use the carburettor choke as sparingly as possible.
(2) Use a compounded variety of oil, i.e. an oil which is essentially mineral in base, mixed with organic fatty oils.

Why has cylinder wear due to piston rings become more noticeable than in the early days of motoring ?

This is primarily due to the demand for engines with a smokeless exhaust and the elimination of fumes from closed carriages. Increased attention has therefore been given to the use of some form of piston ring control to prevent excess oil from finding its way past the piston. Certain types of piston ring control have led to increased ring wear.

How can a faulty thermostat affect cylinder wear ?

The cylinder life is adversely affected if the engine is run at too low a temperature: the hotter the engine—short of boiling point—the less will be the amount of cylinder wear. For example, tests have shown that the amount of wear with the engine running at

50 degrees Centigrade is some eight times as great as it would be with the engine at 100 degrees Centigrade. In practice, an engine should not be run at less than approximately 63 degrees Centigrade (145 degrees Fahrenheit).

What are the chief causes of scored cylinders ?

(1) Loose gudgeon pin.
(2) Broken or jammed piston ring.
(3) Faulty lubrication.
(4) Cracked or broken piston.
(5) Sand or grit drawn in through the induction valve.

The last mentioned cause is never found in engines fitted with air cleaners.

What are the chief requirements for satisfactory piston performance ?

The three rules to which pistons should conform are:

(1) The rings must be a correct fit in the grooves.
(2) The gudgeon pin must be slack in the bosses.
(3) The piston must not be too slack in the cylinder.

In connection with (2), it should be noted that in some alloy pistons the gudgeon pins are a tight fit, whereas with other types it may be necessary to boil the piston before fitting the pin.

What are the symptoms of piston trouble ?

Loss of compression and power; excessive lubricating oil consumption with rapidly shortening periods between decarbonising being necessary.

What are the usual causes of piston and piston ring noise ?

(1) Excessive piston clearances as a result of piston or cylinder wear, or the use of unsuitable replacements.
(2) Replacement pistons or rings striking a ridge worn previously at the top of the sleeve.

(3) Broken piston rings.
(4) Excessive piston ring groove clearances.
(5) Collapsed pistons.

What is piston slap ?

It is a noise caused by wear of the piston body or skirts, and/or, the cylinder bore which allows the piston to "slap" each side of the bore alternately owing to the angular thrust of the connecting rod. It is generally most audible when the engine is running light and gets fainter when the engine is accelerated.

How can piston slap be located ?

The particular piston at fault can often be identified simply by shorting each sparking plug in turn and noting when the slap disappears. More accurate results can be obtained if the test is carried out with the hand-brake fully on, a gear engaged, and the clutch just sufficiently engaged so that a load is applied to the engine while it is running at a fast idling speed.

What is the best way of dealing with piston rings which are tightly carboned in their grooves ?

Break them with a narrow chisel, taking care not to damage the grooves or lands of the piston. Then clean the grooves with a hand scraper and fit new rings.

What faults should you look for in connecting rods ?

When an engine is found to require a big end repair, it is almost certain that it has been subjected to a strain far greater than would be the case in the normal running of the engine. Connecting rods, particularly those which have a split at the small end for securing the gudgeon pin, should be cleansed and examined for fractures. These rods often have a curf running from the gudgeon-pin hole down the rod and, if the engine is operated after the big end metal has run out, it is quite likely

that the curf will develop a crack that can be easily missed unless the rod is inspected carefully.

The faces of the big end of the rod are also likely to be distorted, and therefore must be refaced if the rod is to be used again. Where any doubt exists, it is wise to fit a new rod. After cleaning, the rod should be examined for severe twists or other such faults.

How should a connecting rod be aligned ?

Before refitting a repaired connecting rod it should be checked in an aligning jig of known accuracy, and final adjustments made by means of a connecting-rod straightening tool. Rods should not be corrected by striking them with a hammer whilst they are resting on two pieces of iron laid on the anvil.

The aligning jig should be placed in a good light so that the operator can accurately gauge the light space between the rod and the jig, and should have two sets of feeler gauges. Check each adjustment twice, and change the rod on the testing arbor as a cross-check.

How can main bearing knock be identified ?

Usually by its dull, heavy, metallic sound which rises in frequency with increasing engine speed and which becomes more pronounced with an increase in load. Bearing knocks are generally most noticeable when the engine is running very slowly, and tend to diminish when the ignition is retarded.

What are the usual causes of a main bearing knock ?

(1) Worn crankshaft journal and/or bearings.
(2) Excessive bearing clearances.
(3) Low oil pressure.
(4) Unsuitable grade, diluted or insufficient oil.

What are the symptoms of an engine knock caused by excessive crankshaft end float ?

Such a knock is generally most noticeable with the

engine idling, and may disappear with the operation of the clutch.

How would you distinguish between a big end bearing knock and a main bearing knock ?

The thud produced by a big end bearing is lighter than that of a loose main bearing, and is usually most pronounced at engine speeds corresponding to a road speed of about 30 m.p.h.

Describe a test for big end bearing knock.

Detach and then reconnect the lead from each sparking plug in turn while opening the throttle. Where there is bearing slackness or misalignment of the connecting rod a slight thud will be heard when the lead is replaced.

How may connecting rod small end knocks be caused ?

In some engines, the gudgeon pin floats in the piston and the bearing, and slackness in either the small end bush or the piston bosses will cause a knock. Points to check include the fit of the gudgeon pin, and the alignment of the connecting rod. A tight gudgeon pin may occasionally cause piston slap.

What type of engine faults are likely to be found in a car that has been involved in an accident ?

Accidental damage to the engine usually results in a part of the main casting being broken, such as the fan-bracket support, engine-bearer supports, dynamo bracket, etc. It is possible to repair many of these breakages without completely stripping the engine, and this, of course, results in a considerable saving in the cost of repair, quite apart from the fact that an engine which has done a considerable amount of work usually develops more noise after it has been taken to pieces and re-assembled unless it is given a complete overhaul.

What are the usual effects of frost damage on an engine ?

Frost damage usually results in the fracture of some part of the water jacket. If this is repaired by welding, it will in most cases necessitate reboring and the fitting of new pistons as well as the refitting of all bearings, and this will make the repair an expensive one. On the other hand, there are now available processes for repairing cracked water jackets which in many cases obviate the necessity of stripping the engine. The repairer should, therefore, satisfy himself or obtain the advice of a specialist regarding the possibility of repairing the engine without completely dismantling before proceeding with the work.

Section 2

CARBURETTORS

GENERAL

How would you test an engine for good carburation ?

With the car stationary, allow the engine to tick over, then suddenly depress the accelerator pedal to its full extent. The engine should accelerate smoothly. Bad carburation will be indicated by the engine spluttering, misfiring, firing in the silencer, or staggering, i.e. gathering speed in a jerky fashion instead of smoothly.

The above is a very searching test of the carburettor.

What faults other than the carburettor may give rise to similar symptoms of unsatisfactory engine performance ?

Before carrying out a detailed examination of a suspected carburettor, it is generally advisable to check other components that could have a similar effect upon engine performance. These include:

(1) Loss of compression of one or more cylinders.
(2) Incorrect spark plug gaps.
(3) Oily or dirty spark plugs.
(4) Sticking valves.
(5) Badly worn inlet valve guides.
(6) Defective fuel pump or choked fuel filter.
(7) Leakage at the joint between the carburettor and engine flange, or between the induction pipe flanges and the cylinder head or block.
(8) Incorrectly adjusted contact-breaker gap.
(9) Dirty or pitted contact-breaker points, or other ignition defects.

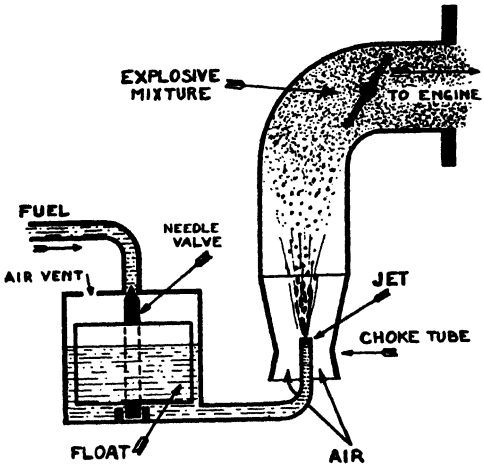


FIG. 5.—SIMPLE DIAGRAM SHOWING THE OPERATION OF A CARBURETTOR.

What should be the prime aim when investigating high petrol consumption?

Correct diagnosis of the exact position of the throttle at which excessive richness occurs.

How would you locate this position?

This can be found by running the engine up light and listening to the exhaust note. Heavy, lumpy running, generally with black smoke from the exhaust, indicates an over-richness in the mixture.

The amount of opening of the throttle valve during this test will indicate whether the richness occurs over the whole of the throttle range or is located at the pilot end, the intermediate jet stages, or the main jet sector.

What faults could cause an excessively rich mixture at all throttle control settings ?

A punctured float, worn needle or needle seating, or a pressure being set up by the mechanical pump which is too great for the needle valve to withstand.

What is a common cause of petrol wastage ?

An incorrectly adjusted pilot air screw. On the majority of vehicles this adjustment controls the amount of air to the slow-running assembly. If this is set on the rich side there will be considerable petrol wastage, particularly when the vehicle is used for town work.

What are the causes of "banging" in the silencer on overrun ?

This symptom can be caused by faulty pilot adjustment or by an air leak in the silencer system, either in the silencer itself or at one of the exhaust flanges.

Can petrol consumption be reduced by using smaller carburettor jets ?

Generally it is a fallacy to believe that the usage of smaller sizes of jets than those fitted will result in a saving in petrol, since for a given speed the throttle has to be opened much more on a very thin mixture than would be necessary with the correct mixture.

What are the symptoms of an engine running with the idling device set too rich ?

The engine surges in speed with a rhythmic beat which gradually gets longer until it fails to run. Black smoke is also visible from the exhaust.

What are the symptoms of an engine running with the idling device set too weak ?

Engine is difficult to start without using the strangler when hot, fires in an irregular manner and stops.

Why do unequal tappet clearances, especially of the exhaust valves, affect idling ?

An alteration in tappet clearance alters the exact time of opening and closing of the valve, this in turn altering the quantity of burnt gas that always remains in the cylinder head at the end of the scavenging stroke. The burnt gas affects the idling mixture, and, if of different amounts in various cylinders, gives erratic idling.

How can throttle-bias be remedied on an engine fitted with a carburettor having the throttle spindle in wrong direction ?

By fitting a distance piece between the carburettor and the induction pipe, the length of which is at least twice the inside diameter of the pipe.

What are the symptoms of a partially choked air-vent hole in tank filter cap of a car with gravity petrol feed to carburettor ?

Engine will start up and run, but shows signs of weakness after a short time, especially when the throttle is opened. If engine is switched off and allowed to stand for a short while, the trouble disappears for a minute or two and then reappears.

If there is no air vent to the float chamber of a carburettor, what fault will be evident ?

Carburettor will flood badly when petrol is turned on.

If inside end of float chamber counterweights touch the neck of needle collar, what is the best remedy ?

The small end of the weights should be filed away in the centre with a fine-cut round file until they just clear the collar.

S. U. CARBURETTORS

What are the indications that the carburettor piston is sticking ?

Either stalling and a refusal of the engine to run slowly or, alternatively, lack of power accompanied by excessive fuel consumption.

How would you detect this fault ?

Where the carburettor is not fitted with an air cleaner, or where the air cleaner or air pipe are readily detachable, the piston may be examined without difficulty. In cases where the removal of these parts is troublesome, an indication of piston movement is obtained by inserting a thin rod, nail, or the like, through one of the atmospheric holes usually provided beneath the overhanging part of the flange which supports the suction chamber. In certain recent types, however, these holes are absent, but it will be found that a projecting spring-loaded pin is provided for this purpose; in other cases a small screw will be found centrally situated beneath the main air intake—removal of this screw enables the thin rod or nail to be inserted.

What would you look for when carrying out this test ?

Normally the piston should rest, when the engine is not running, on the bridge. When raised to its highest position against the appreciable resistance of the damper piston and then released, it should drop freely and strike the bridge sharply and distinctly.

If the piston sticks, or will not break away freely from its resting position on the bridge, the jet should be lowered by means of the enrichment mechanism, and the test repeated.

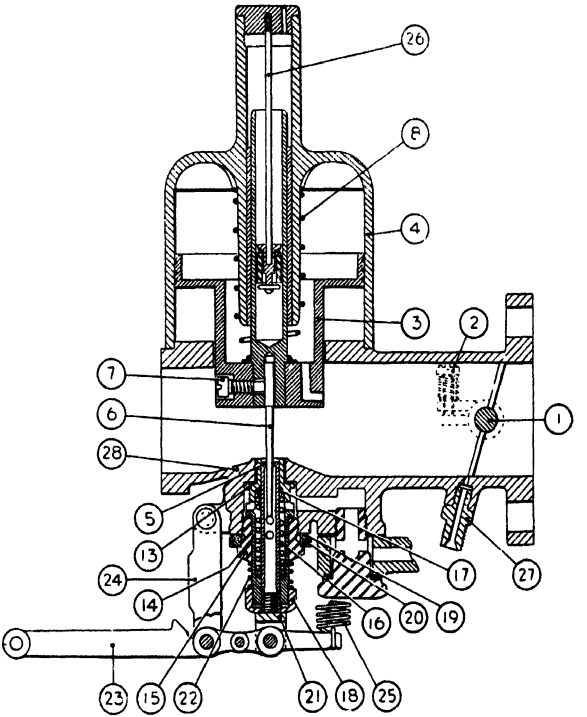


FIG. 6.—TYPICAL HORIZONTAL-TYPE S.U. CARBURETTOR.

1. Butterfly-throttle spindle; 2. Adjustable idling stop screw; 3. Piston; 4. Suction chamber; 5. Fuel jet; 6. Tapered needle; 7. Setscrew; 8. Compression spring; 13 and 14. Jet bushes; 15. Locking screw; 16. Compression spring; 17. Sealing gland; 18. Nut; 19. Sealing gland; 20. Brass washer; 21. Jet head; 22. Loading spring; 23. Jet lever; 24. Link member; 25. Tension spring; 26. Rod; 27. Throttle edge connection; 28. Bridge.

What faults would you suspect if the piston continues to stick ?

This will indicate either that the piston diameter has become enlarged and is making contact with the bore of the chamber, or that the piston rod is not sliding freely within its bush; another possibility is that the damper rod has become bent.

What is the correct procedure if there is dirt or contact between the piston and suction chamber, or sticking of the piston ?

The suction chamber should be removed, and the piston withdrawn. Then thoroughly clean both parts with petrol. Apply a few drops of light oil to the piston rod, preferably diluted with paraffin if any signs of rust are noticed on the rod.

Replace the piston and check whether it now slides and turns freely. If it is found to scrape at some point, due to an indentation of the suction chamber, the resulting "high spots" in the suction chamber bore may be removed by the careful use of a hand scraper. On no account should any attempt be made to enlarge generally the bore, or to reduce the diameter of the piston, as the maintenance of a limited clearance between these parts is essential.

What fault is indicated by flooding from the float chamber or mouth of the jet ?

The most likely causes are a punctured and petrol-laden float, or dirt between the float chamber needle valve and its seating. To remedy these defects it will be necessary to remove the float chamber lid.

How would you proceed if you observed leakage from the bottom of the jet ?

Persistent slow leakage in the neighbourhood of the jet head is usually an indication that the jet gland

washer and its lower counterpart, together with the locking screw washer, require replacement. After reassembly, it will be necessary to re-centre the jet in relation to the needle.

How can the jet be re-centred in relation to the needle ?

This will be necessary should the jet have become displaced in service, or if the parts have been removed for any purpose. The jet stop-nut should first be screwed upwards to its fullest extent, the jet head then being raised to contact it so that the jet assumes its highest possible position. The locking screw should now be just sufficiently loosened to release the jet and jet bush assembly, and permit this to be moved laterally. The piston should now be raised and then, with the jet still in its highest position, allowed to drop. The needle will be driven into the jet mouth and centralised. The locking nut should be tightened and the jet returned to its normal position. If any displacement occurs when the locking nut is tightened, the operation must be repeated.

What action would you take if there appears to be water or dirt in the float chamber ?

If trouble due to this cause is suspected, the float chamber should be examined and cleaned out. Where excessive dirt has been present, the possibility that the jet may have become choked should not be overlooked. If it is convenient to remove the jet and its associated parts, the following expedient may be attempted:

Drop the jet to its fullest extent, remove the suction chamber and piston, then replace the chamber alone. Block the main air inlet, and turn over the engine, rapidly but briefly, by means of the starter motor or by hand. This action will usually draw out any foreign matter from the jet and its associated passages.

What may cause the float chamber needle to become stuck to its seating ?

Where the engine is found to stop under idling or light-running conditions despite the fact that a good supply of fuel is present at the float chamber inlet union, it is possible that the float chamber needle has become stuck to its seating. This may be caused by the presence of some gummy substance in the fuel such as polymerised gum—usually the result of long storage of fuel in the tank. To cure, clean the needle and needle seating with alcohol. Persistent trouble of this nature may require complete mechanical cleaning of the tank and fuel systems.

How may sticking of the jet be overcome ?

Should the jet operating mechanism become stiff, the jet should be lowered to its fullest extent and the exposed lower part smeared with Vaseline; also oil the linkage pins, and raise and lower the jet several times to ensure that the lubricant reaches all parts of the mechanism.

SOLEX CARBURETTORS

When tracing faults on carburettors, why is it advisable to proceed systematically and make only one adjustment at a time ?

If more than one adjustment is made at the same time, it will be impossible to ascertain which was the successful adjustment.

What are the most likely causes of flooding of the carburettor ?

(1) Loose external joints.
(2) Grit on the needle seating.
(3) Punctured float.
(4) Excessive fuel pressure.

(5) Stoppage in the petrol supply.
(6) Bad slow running.

What is the first thing to do in the case of flooding ?

Examine the external joints to see whether any are loose.

When is grit on the needle seating most likely to occur ?

Provided that the carburettor is fitted with a filter, this condition seldom occurs except occasionally within the first few miles after fitting. In these cases the trouble is usually due either to stray particles of packing material or to particles of oxide or solder getting loose inside the petrol pipe.

How would you deal with this fault ?

Remove the needle valve and clean it, carefully blowing it through, and checking that it is hermetic. Then replace it, making sure that the washer is in good condition and is adequately tightened.

How would you repair a damaged needle valve seating ?

Never attempt to grind in a needle valve. Where the damage to the seating is only slight, a new seating can be made by removing the complete needle valve assembly from the carburettor, placing it on a hard surface, and lightly tapping the needle home, rotating it after every two or three taps.

How would you ascertain whether or not the carburettor float is punctured ?

Where petrol has entered the float, its weight is increased and this in turn results in a rise in the fuel level and flooding via the jets. To check the float and locate

the leak, if any, immerse it in boiling water and watch for the emergence of bubbles. A temporary repair can be made by soldering the leak, but this should be regarded as an emergency measure only, since the solder will alter the weight of the float: a new float should be fitted at the earliest opportunity.

How can excessive fuel pressure be caused ?

With mechanical and electrical fuel pumps, it sometimes happens that the pressure developed is in excess of normal, and flooding or excessive consumption of petrol occurs. The correct procedure is to have the fuel pump tested and adjusted, but a compromise remedy is to fit a needle valve one size smaller than standard. The pressure should not exceed 2 lb. per square inch.

What faults may give rise to a stoppage in the petrol supply ?

When investigating a fault of this nature, it is advisable to first check that the petrol tap is turned on, and that there is petrol in the tank; then unscrew the petrol pipe at its union and check that the pipework is clear of obstruction.

A stoppage may also be caused by an air lock in the pipe: this fault is most likely to occur soon after fitting.

Vapour locks can also occur where a petrol pipe runs too near an exhaust manifold or other source of heat.

When checking the pipes union connecting the fuel pump to the petrol tank, it should be remembered that any leakage at these unions may cause difficult starting.

What are the most likely causes, other than incorrect adjustment of the slow-running control, of unsatisfactory idling ?

If satisfactory slow running cannot be obtained, the most likely fault is air leakage at some point in the induction system, probably via the gap between worn inlet-valve stems and their guides. Where the leakage is not excessive, it is possible to overcome this difficulty by

using a slightly larger auxiliary jet: too large a jet size, however, will cause the engine to "hunt". Before altering the jet, first make certain that the jet is free of any obstruction.

Where the leakage is excessive, the engine will not idle regularly, and when any attempt is made to reduce the idling speed this will generally result in the engine stalling. Air leakage in such a case can be confirmed by depressing the tickler (if fitted) and noting whether this causes the engine to pick-up temporarily.

What faults would you look for where the maximum speed of the engine is too low?

(1) Butterfly valve not opening fully. Check that this valve opens to the maximum extent possible when the accelerator is fully depressed, by observing the position of the limit screw which should be in contact with the boss cast on the outside of the throttle chamber.

(2) Insufficient ignition advance. A low maximum speed in this case is generally combined with excessive petrol consumption. It can usually be recognised by inability to make the engine knock on a hill when slowing up with a fully advanced spark.

(3) Defective petrol supply. This can be recognised by the resulting standard acceleration up to some particular speed, followed by periodic hesitations and backfiring above this speed, curable always by reducing the throttle. A good test is to remove the float chamber and note the rate of petrol flow from the needle valve.

(4) Silencer choked. This fault is liable to occur after the car has covered a fair distance. It is generally easy to trace by the absence of a clearly-marked exhaust note at the tail pipe and instead, a steady rush of hot air. For confirmation, test the engine with the exhaust pipe disconnected from the silencer.

Is a faulty carburettor likely to cause overheating ?

Only very seldom will the carburettor be to blame, and then only in the case of air-cooled engines. Too much petrol or an excessively weak mixture can raise the temperature slightly, but in no case should this approach the margin of cooling available under normal conditions.

Can knocking be caused by defective carburation?

Yes, although it is much more likely to be due to other causes such as defective plugs, excessive carbonisation, excessive ignition advance, or to mechanical defects producing a similar noise. When knocking is caused by carburation, it can be due only to a weak mixture; this is generally curable by using a main jet one size larger than that fitted.

STROMBERG CARBURETTORS

What faults would you look for where difficult starting is experienced with a Stromberg carburettor ?

It is essential that there is complete freedom of movement of all working parts. To check, disconnect the thermostat at the link and ensure that the strangler valve and the vacuum mechanism work freely.

Where the strangler valve does not close completely, this may be due to the air cleaner connection on the air intake being overtight and thus distorting the carburettor intake.

It may also be necessary to check the fast idle opening of the throttle plate: when the strangler valve is closed, the throttle plate should open automatically to a specified degree. This setting varies according to the type of engine.

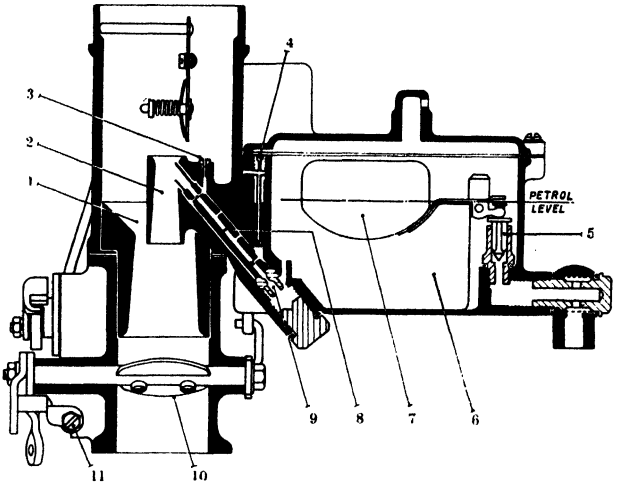


FIG. 7.—STROMBERG MAIN CARBURETTOR SYSTEM.

1. Main venturi; 2. Small venturi; 3. High-speed bleed: 4. Idle tube; 5. Float needle; 6. Float chamber; 7. Float; 8. Main discharge jet; 9. Main metering jet; 10. Throttle; 11. Throttle stop screw.

What would you do if the engine fires but fails to run?

Check the vacuum piston opening of the strangler valve, and make certain that when the piston operates, the strangler valve opens to the correct amount. Here again, the correct figure depends upon the particular type of engine.

How would you check the float level?

It is best to do this with the engine idling, that is with the normal fuel pump pressure. Where the level is found to be incorrect, make sure that the needle seating is clean

and tight, and that the float moves freely on its mounting and is not punctured. If no fault is found, the level may be adjusted by carefully bending the float arm.

How may "flat spots" be eliminated ?

Careful adjustment of the slow-running or idling mixture will usually eliminate flat spots at small throttle openings. It is as well to check the whole of the idling system, ensuring that the idle and progression holes are unobstructed and that the idle tube is clear.

If the flat spot occurs farther up the throttle range, make sure that the main metering jet is of the correct size and is unobstructed, and also that the accelerating pump is functioning correctly.

What are the possible causes of heavy petrol consumption ?

(1) Incorrect carburettor setting. As the settings vary for the type of engine, it is as well to make certain that the settings match the particular type of engine.

(2) By-pass valve sticking or leaking. This condition may be due to the presence of foreign matter keeping the valve off its seating, thus allowing petrol to pass to the main discharge tube at times other than when the throttle is fully open.

(3) Faulty ball valve in the pump discharge assembly. If dirt prevents this component from functioning correctly, petrol may be supplied through the pump circuit at other than the intended times.

ZENITH CARBURETTORS

Describe some of the factors governing successful carburettor tuning.

Slow-running jet. This should be the smallest that will ensure satisfactory idling when the engine is hot and the

air or volume control screw is close to its "full house" position.

Choke tube. This should be the smallest bore that will pass sufficient volume to give the desired top speed and maximum pulling.

Compensating jet. Fit the smallest size that ensures smooth progressive acceleration during the first part of the throttle range.

Main jet. Use the smallest size that gives satisfactory results during the latter part of the throttle range.

Needle and seating. The smallest needle and seating should be used that will allow sufficient petrol to pass when running at maximum engine speed.

What routine servicing is recommended for these carburettors ?

Periodically dismantle the carburettor inlet fuel connection and clean the strainer gauze in the union. It is also advisable occasionally to remove and clean the main and compensating jets. To clean, use fuel and air pressure: do not attempt to pass wire through the jets.

How may climatic conditions affect carburettor settings ?

Should the car be used in very cold climates, larger sizes of jets may be required. In very hot climates, or at very high altitudes, smaller jets should be fitted.

What are the causes of "popping back" ?

If the car pulls away badly and popping back occurs in the carburettor, this may indicate that the compensating jet is too small. Where the popping back occurs at irregular intervals and is accompanied by a lack of power at higher speeds, the main jet is most likely to be at fault, and larger sizes should be tried. Popping in the silencer during downhill coasting would suggest that the slow-running mixture is too weak or that the slow-running jet

is unsatisfactory; however, it should be noted that faulty ignition or sticking valves can also produce similar symptoms.

What faults should be looked for where there is poor starting?

Possible carburettor faults include the strangler valve not closing properly, a choked slow-running jet, or incorrect adjustment of the air regulating screw. Also check that the fastening of the carburettor bowl to the main body has not become loose.

Section 3

FUEL PUMPS

What is the golden rule for fuel pump servicing ?

Do not assume that the pump is inefficient, however strong the indications, without first examining all possible contributory factors.

Describe some of the other and more usual faults that produce symptoms similar to those of an inefficient pump.

Frequent causes of such symptoms (lack of fuel at the carburettor, difficulty in starting, etc.) are leaky, bent, or choked tubing, or inefficient connections. Even apparent leakage of fuel at the diaphragm can sometimes be traced to a fault in the pipe fittings, the fuel having run down the pump in such a manner as to appear to be emerging from the diaphragm flange.

The possibility of unsatisfactory fuel delivery being caused by a vapour lock should also not be overlooked where the pipe system passes close to the exhaust system. Vaporisation may also occur in the pump itself where this is insufficiently cooled or placed too near the exhaust system; the latter fault may usually be cured by fitting a small shield.

A. C. PUMP

What steps should be taken if shortage of fuel persists after checking tubes and connections ?

Where a Series Y, T, or U pump is fitted, examine the filter cover, checking that it is not loose and that the

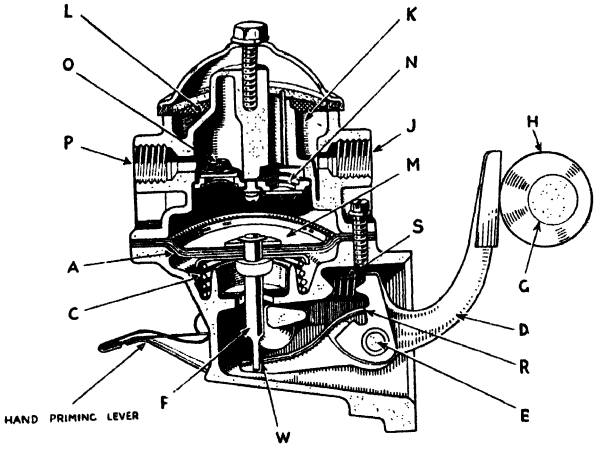


FIG. 8.—SECTIONAL DIAGRAM OF AC SERIES "U"-TYPE FUEL PUMP.

A. Diaphragm; C. Diaphragm spring; D. Rocker arm; E. Rocker-arm pin; F. Pull rod; G. Camshaft; H. Eccentric; J. Fuel-inlet connection; K. Sediment chamber; L. Filter gauze; M. Pump chamber; N. Suction valve; O. Delivery valve; P. Fuel-inlet connection; R. Rocker-arm and rocker-link contact; S. Rocker-arm spring; W. Rocker link.

cork gasket makes an airtight joint without undue pressure. Also check that the filter screen is not dirty.

Where the pump is fitted with a glass bowl, examine this to ensure that it is not loose and that the cork gasket lies flat in its seating: here again check that the filter screen is not dirty.

How may leakage of fuel at the edge of the diaphragm be rectified ?

This trouble can sometimes be cured without removing the pump by checking the cover screws: should these be loose, tighten them alternately.

Can a faulty pump be the cause of flooding ?

The pump is never wholly the cause, but may aggravate it as the result of air being drawn in through leaky pipe joints or the filter gaskets.

How would you deal with a noisy pump ?

While the normal cause of noisiness in pumps—worn or broken parts—can only be cured by dismantling and replacing the affected components, it is as well before commencing this operation to make quite sure that the source of noise does not lie in the engine itself.

TECALEMIT DL- AND DR-TYPE PUMPS

What are the likely causes of lack of fuel in the carburettor float chamber ?

Possible Cause	*Remedy*
(1) Fuel tank exhausted	Replenish tank.
(2) Loose pipe unions	Tighten all connections in the petrol-supply system.
(3) Damaged piping	Renew where necessary.
(4) Filter cover nut loose	Remove bowl, examine cork joint, renew if necessary, tighten bowl nut.
(5) Filter choked	Remove bowl, wipe gauze gently with clean rag. (*Note*—The centre bolt and gauze should not be removed for this operation.)
(6) Leaking valve plug- outlet	Tighten with a spanner the hexagonal nut beneath the air dome.
inlet	Remove centre pin by passing small tommy bar through the fuel duct, unscrew and release gauze. Tighten plug by means of a wide screwdriver in slot.

(7) Bent or damaged valves. (This fault is unlikely to occur unless the pump has been tampered with.)	Remove valve plugs and valves. Carefully cleanse in petrol and examine valves and valve seats for defects. Tecalemit fuel pump valves are interchangeable, and care should be taken to see that they seat flat and are not on edge when being replaced. The valve springs should be handled with care. The inlet and outlet valve springs are not interchangeable.

What fault could cause a leakage of fuel at the diaphragm flange ?

This fault could be caused by loose screws in the flange, although the design of the flange makes this possibility remote. If it should occur, the remedy is to tighten all screws equally and gently in rotation.

What is a possible cause of flooding of the carburettor ?

The carburettor needle valve not seating. The remedy is to examine and adjust the carburettor. Clean the float chamber and the needle seat.

When and how should the priming lever be used ?

The priming lever is for use only when the engine is at a standstill, with empty fuel lines and carburettor. The correct method of operation for priming is to push the lever down and release. This should be repeated until fuel emerges from the carburettor, when "tickler" is used to depress the float. Normally a few turns of the engine should preclude the need for priming.

S.U. ELECTRIC PUMP

Describe the three main types of faults to which all electrical accessories are subject.

(1) Failure of the electrical supply circuit owing to breaks or short-circuits in the supply cables, breakdown of the controlling switch, or poor contacts at terminals or cable connectors.
(2) Inadequate or faulty earth connection.
(3) Fault in the unit.

How would you set about locating trouble in the pump ?

If the pump is not heard to operate although there is petrol in the tank, disconnect the petrol delivery pipe from the pump; should petrol now be ejected from the pipe, the most likely cause of trouble is a sticking needle valve in the float chamber of the carburettor.

Should, however, the pump still not respond, disconnect the supply union; if the pump now begins to function, the fault is most likely to be a choked supply line and this may be cured with the aid of compressed air.

Dirty contacts may cause failure of the unit: these should be cleaned by holding them together and passing a piece of emery card between them. The contact gap should be 0·03 in.

Failure of the points to operate may also be caused by a hardened diaphragm, or by obstruction of the roller by foreign matter. To rectify these faults, the pump should be stripped and cleaned.

What are the most likely causes of a noisy pump ?

If there is plenty of petrol in the tank, the most likely cause is an air leak on the suction side. To trace such a leak, disconnect the petrol pipe from the carburettor and allow the unit to pump petrol into an oil measure, with the end of the petrol pipe submerged in the petrol: air bubbles will indicate a leak.

Noisy operation may also be due to the petrol boiling before it reached the pump: this is most likely to occur in hot weather after hard running. It is usually caused by the petrol pipe being positioned too near the exhaust pipe, and can often be cured by placing an asbestos shield between the pipes.

What fault would you suspect if the pump functions mechanically but does not deliver petrol ?

A common cause of this fault is that a piece of dirt has become lodged beneath one of the valves. This can be removed by unscrewing the top union and lifting out the valve cage: when replacing take care that the washers are fitted in their correct sequence (thin red fibre below the valve cage, thick orange one above it).

A choked filter or obstruction to the inlet supply will cause the pump to run at a very high temperature, and if not cleared, will burn out the pump.

Section 4

COOLING AND LUBRICATION

RADIATORS AND COOLING SYSTEM

What tools are required for the repair of leaking radiators ?

(1) A soldering iron, average weight 1½ lb.
(2) A gas blow-pipe giving a flame approximately the size of a lead pencil.

Why must great care be taken in the carrying out of radiator repairs ?

The average thickness of radiator tubes is of the order of 0·005 in. and inexpert use of the tools can easily result in the collapse of a section of the tubes.

How may radiator leaks be located ?

The radiator should be removed from the vehicle, and thoroughly swilled out with clean warm water to remove all silt and lime deposit. Then the inlet and outlet pipes and filler neck should be sealed off with air-tight discs of tinned iron (suitable discs may be cut from domestic tins) soldered to the necks of the outlets. A rubber tube, connected to a tyre pump, should be attached to the overflow outlet, and the entire radiator immersed in a bath of water. Leaks can then be located by escaping air bubbles, marked by small metal clips, and subsequently sealed by soldering.

Is it safe to seal off a faulty tube ?

This may occasionally be necessary, but on no account should the original cooling capacity of the radiator be impaired by more than about 15 per cent.

How may a temporary repair be made to a plain-film block type radiator ?

If the leak can be located by observation, it is sometimes possible to plug between the leak and the neighbouring tube by inserting a thin piece of rubber tubing and afterwards pressing into it a small piece of wood, cut and shaved to the required shape.

Should rubber tubing not be available, soap may be used as a temporary plug, as this can afterwards be removed with hot water. On no account should putty, white lead, or any other substance that hardens, be used as otherwise it may later prove impossible to remove the plug.

What radiator faults may cause engine overheating ?

The core may have become encrusted with mud, dirt, or paint, the core tubes choked with silt or lime deposit, or the shutter mechanism inoperative with the shutter permanently closed. The radiator and cooling system must, at all times, be kept well filled, with no leakage from the drain plug, or in the connecting hoses.

How may the cooling system be cleaned ?

By opening the drain plugs and inserting a water hose into the filler neck. The system should then be thoroughly flushed through until the water emerges clean.

Why should soft ("neutral") water be used in cooling systems ?

To minimise corrosion. Should only alkaline or saline water be available, the addition of an anti-corrosion agent is recommended. Potassium dichromate is suitable for mildly alkaline or saline water where aluminium cylinder heads are fitted.

What may cause a low water level in the radiator ?

If the water consistently falls to a level a fixed distance below the top of the overflow pipe, this may be due to a split or crack in the overflow pipe a little below its top level and before it emerges from the tank.

What are the main types of fault affecting water circulation and consequently causing overheating ?

(1) Cylinder waterways blocked by sludge, deposit, or faulty gasket.
(2) Blocked radiator tubes.
(3) Defective thermostat.
(4) Defective water pump.
(5) Deterioration of water hoses.
(6) Loose water manifolds.

What are the more common faults that occur in water pumps ?

(1) A leaky gland or gasket, sometimes noticeable only at high engine speeds.
(2) Shaft, loose or with excessive end play.
(3) Leakage at the inlet or outlet connections.
(4) Impeller blades damaged or rubbing against the pump housing.

Why is it necessary periodically to examine radiator hoses ?

Radiator hoses tend to become hard and perish, and the inner surface to disintegrate and impede the circulation of the water. Hoses found to be thus affected should be replaced.

How may a suspected thermostat be tested ?

Thermostats are normally installed in the radiator top hose on engines incorporating a water pump. Where the operation of this component is suspected, it should be

removed from the hose, after draining the cooling system, and tested by placing it in warm water which is then heated, watching the action of the valve while accurately measuring the temperature of the water. Most thermostats are designed to start to open at approximately 160° F. and to be fully open at about 180° F.

What faults may be caused by incorrect adjustment of the fan belt tension?

Too tight a belt causes excessive wear, especially of the front bearing of the generator, the water pump, and the belt.

Too loose a belt causes pulley slip, resulting in the engine overheating and reducing the generator charging rate.

The correct adjustment of the belt depends upon the particular engine concerned, but is usually of the order of ½-1 in. play when measured at a point midway between the crankshaft and fan pulleys.

What are the more common faults giving rise to the loss of water from the cooling system?

(1) Leakage from the radiator.
(2) Leakage at the hose connections.
(3) Leakage due to defective packing washers in the water pump or thermostat.
(4) Leakage from the cylinder block, due to defective cylinder head gasket, or insufficiently tightened cylinder head nuts.
(5) Water boiling due to engine overheating.

Why is an engine likely to overheat after an overhaul?

There is liable to be higher internal resistance of the moving components, until these have bedded down,

What may be a cause of the water boiling in summer ?

The use of certain brands of anti-freeze mixture which tend to lower the boiling point of the cooling mixture.

LUBRICATION

How would you judge as to whether the lubrication system is in order ?

The oil pressure gauge should register not less than 3 lb. per square inch when the engine is ticking over.

What are the common causes of incorrect oil pressure ?

(1) Inefficient oil pump.
(2) Incorrect grade of lubricant or its use in badly diluted condition.
(3) Restrictions or leakages in oil passages or bearings.
(4) Faulty pressure gauge.
(5) Faulty oil release valve.

What may reduce the pressure exerted by a gear-type oil pump ?

The most likely causes of low pressure are the cumulative effects of wear at the gears, shafts, and cover plate, choking of the oil pump filter screen, or deterioration of the gasket.

How does the viscosity of the oil affect the pressure ?

The use of a thicker, summer grade oil will result in a higher pressure than when using a winter grade oil under the same conditions.

What tests would you carry out if an oil leak were suspected ?

Test	*Remedy*
(1) Check valve cover joints with engine running.	Fit new gasket, straighten cover, fit cover right way round.
(2) Check oil sump plugs.	Tighten, fit new washers.
(3) Check all oil pipe joints and oil ways with engine running.	Remake joints.
(4) Check crankshaft pulley bearing or auxiliary drive-shaft bearings with engine running.	Replace packing or clean oil return grooves.
(5) Check quantity of oil in clutch housing in wet clutches.	Check oil level regulation device.
(6) Look for traces of oil in dry clutches.	Attend to oil retention device at crankshaft bearing. Check for blowholes in sump partition.
(7) Check oil-tightness of clutch inspection cover in wet clutches.	Remake cover joint.
(8) Check oil pump joints on external filters.	Remake joints.
(9) Check leakage of oil past slack valves.	Fit new valves and guides.

How can you test for excessive oil consumption caused by cylinder and piston wear ?

Test	*Remedy*
(1) Observe exhaust for smoke. Listen for piston slap. Listen for "blow by".	Fit over-size pistons if wear not over limit.
(2) Measure cylinder bore wear.	When wear is over limit rebore as well.

(3) Measure piston clearance. Examine fit of piston rings in grooves.	Fit new piston assemblies or clean piston ring grooves and fit over-size piston rings if piston clearance not excessive.

How could excessive oil consumption due to bearing wear be diagnosed ?

Examine the exhaust for smoke and the oil gauge for loss of pressure. To remedy, renew big-end bearings, and in extreme cases main bearings as well. Regrind crankshaft.

Section 5

IGNITION

In the case of a sudden engine stoppage. How would you make an ignition test ?

(1) Feel the porcelain insulators of each spark plug in turn. A faulty plug will be perceptibly cooler than the others.

(2) Remove one plug from its socket, and lay it on the cylinder head. Then turn the engine over by hand or by the starter motor and note whether a spark occurs at the plug points. If no spark is observed it will be necessary to carry out a systematic investigation of the ignition as described in this section.

What two main types of faults are likely to be encountered when servicing coil ignition equipment ?

(1) Complete failure to produce the spark at the plug points.

(2) General deterioration of engine performance.

What is the most likely cause of complete failure ?

This type of failure is usually—but not always—caused by a fault in the low-tension circuit.

What is the cause of general deterioration of performance ?

More often than not, this is caused by a combination of several factors, which may be either electrical or

mechanical. To trace such a fault may require a complete check of the ignition system.

Before commencing a complete check, what preliminary steps should be taken ?

The main electrical system should be examined, and the battery, conductors, and all connections, as far as the lighting and ignition switch eliminated as possible causes of the trouble: faults in these components will normally be revealed in other directions.

Attention should also be paid to the petrol supply system and to cylinder head leakage. Before starting on the tests, a careful assessment of current engine performance should be made so that the results of any alterations may judged.

Where would you look for trouble in a coil-ignition system ?

(1) *Spark plugs.*—Gap small or oversize. Plug oiled or sooted up. Plug points short circuited. Dirt or moisture on insulator.

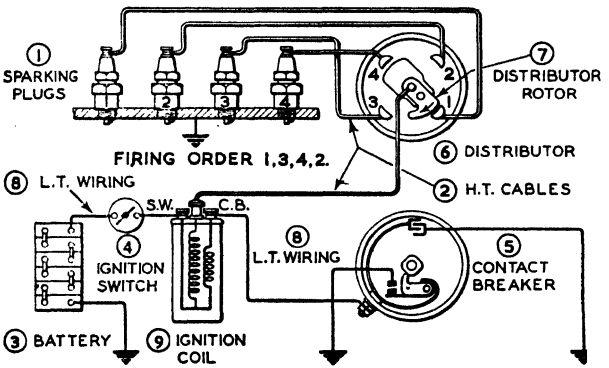


FIG 9.—WHERE TO LOOK FOR TROUBLE IN A COIL-IGNITION SYSTEM.

(2) *H.T. cables.*—Detached connection. Defective insulation. Broken wire in cable.
(3) *Battery.*—Faulty or discharged. Loose or corroded connections. Insufficient acid. (See also page 62.)
(4) *Ignition switch.*—Turned off. Loose connections. Defective cables.
(5) *Contact breaker.*—Rocker sticking. Gap incorrect. Contacts dirty. Contacts worn. Loose connection. Faulty condenser.
(6) *Distributor.*—Water or dust on external surface. Dirty internal surface. Electrodes worn.
(7) *Distributor rotor.*—Wear. Tracking.
(8) *L.T. wiring.*—Defective cable. Detached connection.
(9) *Ignition coil.*—Water or moisture on surface. Loose connection.

What details would you check when servicing spark plugs?

Always use the type of plugs specified by the maker. Plug points should be set between 0·022–0·030 in. for a standard ignition coil. Some six- and eight-cylinder engines may need a gap as low as 0·018 in. for satisfactory performance at all speeds. With high-voltage coils the gap should not exceed 0·040 in.

Plugs should be serviced with a suitable plug cleaner and the insulation kept clean and dry. Cleanliness and good insulation are of particular importance with high-voltage coils and wide spark plug gaps.

What faults are most likely to be found in H.T. cables?

Cables should be carefully examined for signs of cracking or perishing, or of oil impregnation: special attention should be given to points where wires pass beneath clips or enter conduits. High-tension leakage can be detected by running the engine in the dark and watching for a blue haze round the faulty points (do not perform this test in

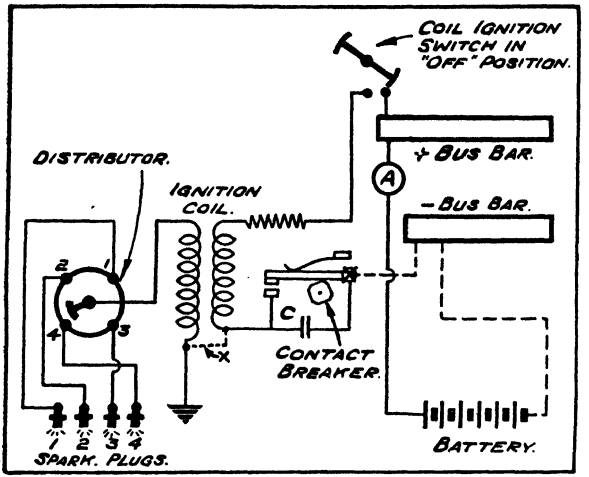


FIG. 10.—DIAGRAM FOR A COIL-IGNITION CIRCUIT.

the garage unless there is adequate ventilation). Also check the points at which the cables enter the distributor and coil mouldings. Where it is found necessary to change the cables, neoprene-insulated conductors are recommended for their high degree of insulation and resistance to oil.

What is the quickest way to detect a faulty spark plug ?

After the engine has been misfiring on one cylinder, switch off the ignition, raise the bonnet and touch the porcelain insulator of each spark plug: the faulty plug will be cooler than the others.

Another method is to short-circuit each plug terminal to the cylinder head with a screwdriver blade (insulated

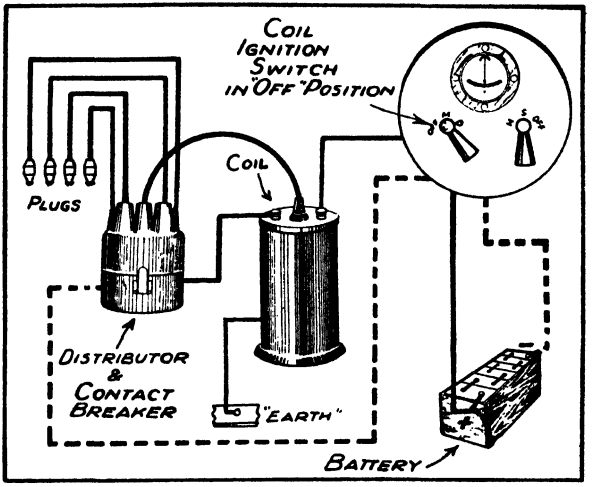


FIG. 11.—PICTORIAL DIAGRAM OF COIL-IGNITION CIRCUIT.
See Fig. 10.

handle) while the engine is running: short-circuiting the faulty plug will not affect the running of the engine.

Is misfiring always caused by a faulty plug?

No, it may be due to a faulty connection between the plug and the distributor or by trouble in the distributor head. Again it may be due to some non-electrical trouble such as a sticking inlet valve.

How would you test whether the fault is in the plug?

Disconnect the H.T. cable from the plug and hold the end of the cable approximately $\frac{3}{16}$ in. from the cylinder head (taking care that the hand is well insulated from the H.T. wire). If there is regular and steady sparking, the

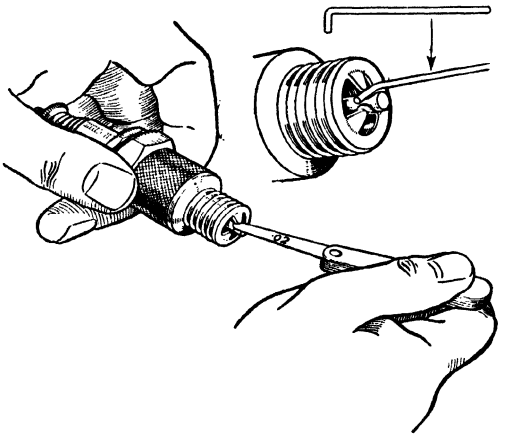


FIG. 12.—MEASURING SPARKING PLUG GAP.

If the centre electrode is badly pitted, the normal feeler gauge will not give a correct reading. A round piece of wire of known diameter is preferable as a gauge in such cases. Do not adjust gap by bending the central electrode.

fault is likely to be in the plug. If there is no sparking, or weak and irregular sparking, the fault is likely to be in some other part of the ignition circuit.

What are the most usual spark plug faults?

(1) Carbon deposit on the points or on the insulator.
(2) Cracked insulator.
(3) Points too far apart.
(4) Points oiled up.

What is the usual cause of excessive deposit of carbon ("sooting up")?

An over-rich mixture. Thus the basic fault lies more often with the carburettor than with the spark plug.

What is the usual cause of an accumulation of dirty oil and carbon on the insulation and central electrode ("oiling up")?

Poor condition of the cylinder or piston rings. Improvement may sometimes be effected by using a plug of lower heat resistance.

If you found the mica insulation to be white and calcined, what might this indicate?

That the plug has been too hot. This may be due to a too weak mixture, or it may indicate that a plug of higher heat resistance is required.

What are the principal causes of insulators splitting?

The most frequent cause is the bending of the centre electrode during adjustment of the plug gap: this sets up a strain which, upon heating, tends to break the insulator. For this reason it is most important always to adjust the side and not the centre electrode.

Another cause is excessive heat; this may be due to a too weak mixture, valves sticking, or not seating properly, or to the use of the wrong type of plug.

How would you detect tracking in a distributor cover?

This appears as spidery, carbonised lines running between the segments of the cover or down to the rim which fits into the main body. Excessive burning of the brass segments of the cover frequently causes misfiring at high speeds and subsequent tracking of the moulding.

For what other faults would you examine a distributor cover?

The carbon brush and spring which make contact with the rotor arm should be examined for freedom of

movement. The cover should be thoroughly clean and dry both inside and outside.

What faults may be found in a distributor rotor ?

Excessive burning of the electrode, loose electrode, tracked moulding. Should it be necessary to replace the rotor, take care to fit the correct type.

What is the correct gap to which contact breakers should be set ?

This depends upon the particular engine concerned. All standard Lucas distributors, other than the eight-cylinder and DM range, should be set to 0·012 in. The correct gap for the eight-cylinder and DM range is 0·014–0·016 in. Generally, a smaller gap than that recommended by the makers leads to excessive pitting and piling of the contacts. Excessive gap will cause misfiring at high speeds.

How should burnt contacts be treated ?

Burnt contacts should be cleaned with a fine carborundum stone until all traces of swarf have been removed. Do not attempt to grind down a pitted contact face; provided a reasonable area of the face is unaffected, satisfactory operation is possible. Should the pitting be excessive, a new set of contacts must be fitted. After fitting new contacts, check gap setting at 200 miles, as the bedding-in of the fabric heel usually leaves the setting on the low side.

Why is it necessary to keep contact points free from oil or petrol ?

An oil film on the contact faces readily oxidises and prevents good electrical contact between the points, which is necessary for good performance at low speeds.

Petrol vapour is particularly harmful to platinum contacts and may cause extremely rapid wear.

What is an indication of the presence of petrol vapour in the contact breaker ?

A black oily deposit on the contact breaker and its cover.

How may wear of the distributor affect the ignition ?

Wear in the bearing bushes, ballraces, cam, or cam spindle may cause uneven opening of the contacts on different cylinders. Maximum permissible side-play is of the order of 0·005 in. and can be checked on the gap setting by applying pressure on the cam, first on the side nearest the contact lever heel, and then on the opposite side.

What faults may affect the automatic timing control ?

Failure to lubricate automatic advance mechanism of the centrifugal type may result in the cam seizing on the spindle. If this occurs in the advance position, back-running of the engine may occur and there may also be pinking or rough running at low and medium speeds. If the cam becomes seized in the retard position, engine performance will be poor with excessive petrol consumption and overheating.

Wear in the toggles controlling the weights may give an excessive range of advance. Variation of the elasticity of the springs may alter the characteristics of the automatic control.

How may a faulty vacuum unit be detected ?

The purpose of a vacuum unit is to advance the timing when the engine is lightly loaded. Since its effect is, relatively speaking, small, the unit may fail completely without the driver becoming aware of this fact. The most noticeable symptoms are a tendency to pink when accelerating coupled with a slight increase in petrol consumption.

On most engines it is possible to check the unit visually, by opening and closing the throttle sharply ("blipping"), when the plunger should be seen to move in and out as the vacuum unit operates.

What are the effects of a faulty condenser ?

A faulty condenser can cause misfiring at all engine speeds or complete failure of the ignition system.

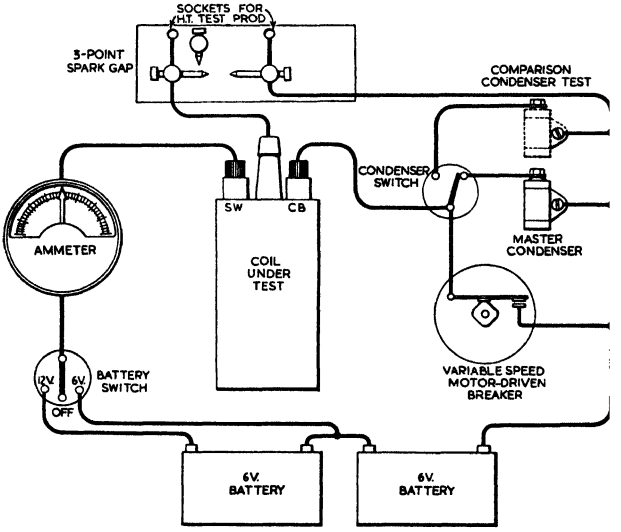


FIG. 13.—TEST CIRCUIT FOR IGNITION COILS AND CONDENSER.

Battery voltage must be checked under test. Ammeter is required for coil current consumption test. Condenser test is made by comparing its performance at the spark gap with that of the master condenser.

What is a good guide to the condition of the condenser ?

The condition of the contact-breaker points. If the points are badly burnt, the efficiency of the condenser should be checked. Look for broken strands in the condenser lead, or defective connections.

Yellowish powder around the edges of the contacts is an almost certain indication to a faulty condenser.

What is the simplest method of checking a condenser ?

Replacement of the suspected component by a similar condenser of known efficiency. If test equipment is available, the insulation resistance of the condenser should be tested and should not be below 1 megohm.

How would you examine a suspected ignition coil ?

The coil moulding should be carefully examined for signs of tracking; it should be kept clean and dry. Examine the low-tension terminals for badly soldered joints and for loose terminal posts. Intermittent breaks, particularly those which occur only when the coil is warm, are sometimes difficult to locate unless the coil is warmed before testing.

What special precautions are necessary when dismantling magnetos ?

(1) That such parts as earthing brushes and safety spark gap screws are removed first to avoid damage to the slip ring.

(2) That the magnet poles are bridged by a substantial soft-iron keeper before the rotor is withdrawn or the magnet removed.

MAGNETO FAULT-FINDING CHART

Symptoms	*Possible Causes of Trouble*
(A) MISFIRING CYLINDER	(1) H.T. cable detached; (2) Faulty insulation; (3) Wires broken in cable; (4) Plug fouled or defective; (5) Very large plug gaps; (6) Tracking over distributor surface—externally to earth—internally between segments.
(B) MISFIRING ON HALF THE CYLINDERS	(1) Contact gaps unequal—is timing control rod tilting cam tube?
(C) MISFIRING IRREGULARLY ON ALL CYLINDERS AT ALL SPEEDS	(1) Contacts dirty, pitted, or worn; (2) Contact gaps small; (3) Loose contact screw; (4) Broken contact spring; (5) Contact lever movement sluggish; (6) Loose fixing screw; (7) Dirt or moisture on distributor surface (see A6); (8) Plug gaps large; (9) Plugs leaky; (10) Carbon deposit on slip ring and collector moulding; (11) Carbon brush sticking; (12) Faulty collector, brush holder, or slip ring; (13) Badly worn distributing electrode or segments; (14) Faulty secondary winding.
(D) MISFIRING IRREGULARLY ON ALL CYLINDERS AT HIGH SPEED	(1) Contact gaps large; (2) Contacts dirty, worn, or pitted; (3) Contact screw loose; (4) Contact-breaker fixing screw loose; (5) Switch cable faulty; (6) Contact lever sluggish; (7) Also as C9 to C14.
E) MISFIRING WHEN IGNITION FULLY ADVANCED	(1) Contact gaps large or contacts worn; (2) Plug gaps large; (3) Plugs very leaky; (4) Secondary winding failing.
F) MISFIRING ON HILLS WHEN ACCELERATING OR TIMING RETARDED	(1) Plug gaps large; (2) Plugs leaky; (3) As A6 and C7; (4) As C13; (5) Contact gap large; (6) As C10; (7) As C12; (8) Secondary failing.
(G) MISFIRING AT LOW SPEED AND BAD STARTING	(1) Contacts dirty; (2) Contact-breaker fixing screw loose; (3) Contact lever movement sluggish; (4) As E1 to E4 inclusive.
(H) ENGINE WILL NOT START (NO SPARK FROM PLUG CABLE TO EARTH)	(1) Excessive moisture on distributor; (2) Oil or dirt on contacts; (3) Contact lever sticking; (4) Broken contact lever spring; (5) Contact gap small; (6) Moisture or carbon deposit on slip ring and collector; (7) Switch cable earthed; (8) As C12, 13, and 14.
(I) ENGINE WILL NOT START (MAGNETO O.K.)	(1) Plugs very leaky due to moisture externally and internally; (2) Plug gap large.
(J) LOW MAXIMUM ROAD SPEED	(1) Contact gap large; (2) Contacts dirty, worn, or pitted; (3) Contact lever sluggish; (4) Secondary failing.
(K) ENGINE GETS UNDULY HOT	(1) Ignition retarded; (2) Incorrect engine timing; (3) Plug gaps small.

Why is it important to bridge the magnet poles before withdrawing the rotor ?

Because if this is not done, the magnetic circuit will be broken, and the permanent magnetism will be partially destroyed. Unless the magnet is remagnetised before reassembly, the magneto will not deliver a sufficiently strong spark, especially at low engine speeds.

How would you trace a fault on a magneto ignition system ?

By using the chart given on page 60.

Section 6

BATTERIES, DYNAMOS AND STARTER MOTORS

BATTERIES

What are the usual indications of battery trouble ?

Dull lights and refusal of starter to operate.

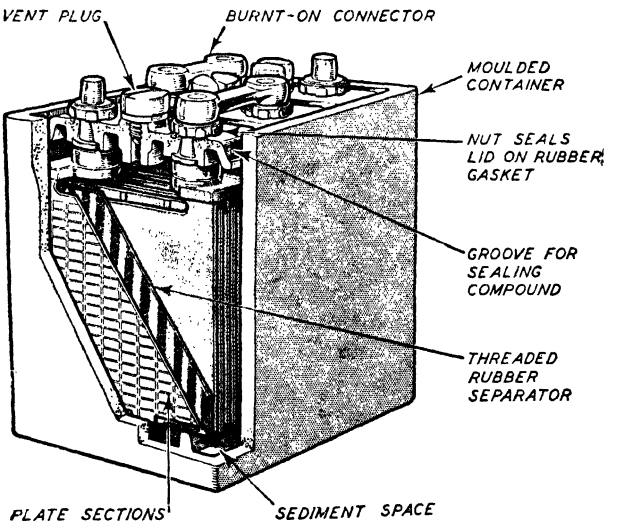


FIG. 14.—CONSTRUCTION OF A TYPICAL CAR BATTERY (*C.A.V.*).

What are the two important factors to consider when testing a battery?

(1) The state of charge of the battery.
(2) The condition of the battery.

This is important because a battery that is in good condition will operate satisfactorily when only partially charged, whereas one in poor condition may not function satisfactorily even when fully charged.

What three tests would you make on a faulty battery?

(*a*) Gently prise up the cell connectors with a lever to see if they have worked loose.
(*b*) Take a reading of the specific gravity of the acid, using a hydrometer.
(*c*) The high rate discharge test. This test is simply taking a voltage reading whilst a heavy current is being drawn from the cell.

Describe the hydrometer test.

The test depends upon two facts. First, there is the fact that a fully charged accumulator has the sulphuric acid at a definite specific gravity. The value varies with the make and type of battery but is often 1·280 to 1·300, with acid temperature of 60° F.

The second fact is that during discharge, the specific gravity of the acid gradually falls owing to the fact that the heavy sulphion (SO_4) combines with the material on the plates to form lead sulphate. Reduction in the specific gravity, therefore, provides a sure indication of the amount of sulphating which has occured. The method of conducting the test is as follows:

The filler cap from each cell is removed and the hydrometer is inserted in the acid. The hydrometer bulb is then released so that it draws up a small quantity of acid into the tube, which contains a float. The stem of the float is graduated, and the position it takes up in the acid enables the specific gravity to be read off.

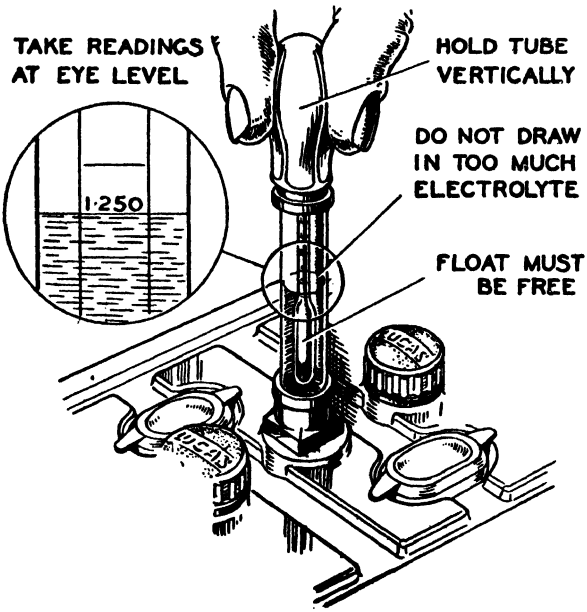


FIG. 15.—METHOD OF USING HYDROMETER.
The correct reading is the line on the float cut by the surface of the liquid.

How would you interpret the hydrometer reading?

1·300–1·285	Battery fully charged.
1·250–1·210	Battery half charged.
1·150	Battery quarter charged.

Any considerable variation in the readings of one cell in relation to the remainder can be taken as an indication

that that particular cell is either faulty or, alternatively, is being affected by some external factor. The specific gravity of a faulty cell will often approach that of water (1·000).

What fault would you look for if the hydrometer test reveals that one cell has a very low electrolyte level ?

Examine the battery container for signs of seepage through a crack. A cracked container cannot be satisfactorily repaired, but if the battery is otherwise in good condition a new container can be fitted by firms specialising in this class of work.

How would you carry out a high-rate discharge test ?

The tester is applied across each 2-volt cell in turn, the prongs being held firmly in contact with the cell connector for 10 seconds and the voltmeter reading noted. The duration of the test is important, and should be the same for each cell. The voltage to be noted is that shown at the end of the 10-second period.

Fig. 16 shows the tester being applied to the battery cell and Fig. 17 illustrates the rearrangement of the prongs, should this be required.

How can the readings be interpreted ?

1·6–1·4 volts	Battery fully charged.
1·4–1·2 volts	Battery half charged.
1·2–0·4 volts	Battery quarter charged.

A battery in good condition should show equal readings for each cell, though a difference of 0·1 volts would generally be considered satisfactory.

A faulty cell incapable of further useful work will be indicated by its inability to hold any voltage during this test.

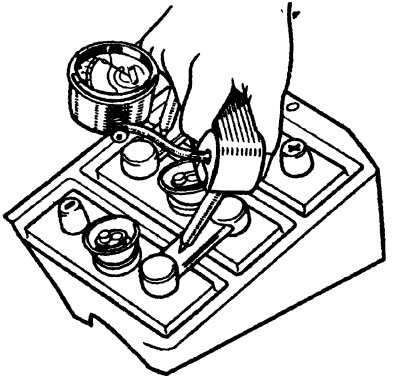


FIG. 16.—THE HEAVY DISCHARGE TEST.

The tester is applied across each 2-volt cell in turn, the prongs being in contact with the connector for 10 seconds.

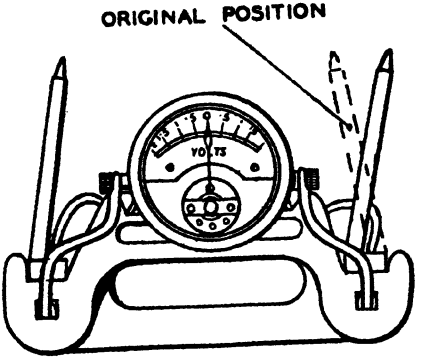


FIG. 17.—TYPICAL DROP TESTER OR HEAVY DISCHARGE TESTER.

When testing some batteries it is necessary to alter the prongs owing to the differing centres of intercell connectors.

What procedure would you adopt if the readings are low and there is doubt as to the condition of the battery ?

Remove the battery from the vehicle and charge from an independent source at one-tenth of the rated capacity of the battery for at least four or five hours and then repeat the tests. Rapid recharging methods should not be applied to a suspect battery.

What is the most likely cause of conflicting hydrometer and heavy discharge test readings ?

This is almost certainly due to acid of the wrong specific gravity being contained in the cell. In such cases, the battery should be removed from the vehicle for recharging and correction of the specific gravity.

What fault would you look for if one or other of the end cells gives a poor response to both tests but is not completely discharged ?

Visual examination will often show that a cable lug is badly corroded and has caused a partial short-circuit across the cell. A surface leakage across one or more cells may also be caused by water leaking on to the battery from the radiator or thrown up from the roadway.

How can inspection of the electrolyte prove a useful guide to the general condition of the cell ?

If the readings are low and the electrolyte drawn into the hydrometer is observed to be cloudy or dirty, it can usually be assumed that the plates are shedding their active material, and a repair or replacement is necessary.

What is the effect of leaving a lead-acid battery in a discharged condition ?

One of the chemical changes associated with the discharge of a lead-acid battery is the formation of lead

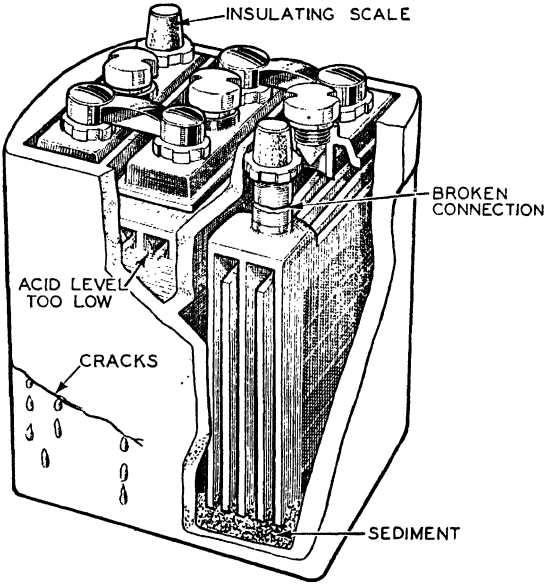


FIG. 18.—SOME OF THE POSSIBLE FAULTS IN A LEAD-ACID BATTERY.

sulphate on the plates. If the battery is left in this condition, the lead sulphate hardens and becomes resistant to further chemical changes—it becomes more difficult to charge. This condition of a battery or cell is known as "sulphation".

Is this the only cause of sulphation ?

No, discharging cell below 1·8 volts and neglecting to top up are other causes of sulphation.

What are the indications of sulphation?

Sulphated cells will commence gassing in the early stages of charge owing to the fact that the plates are not in a condition to absorb all the gas evolved by electrolytic action.

The cells are inclined to get hot and the voltage is liable to be high on charge. The specific gravity will be low. A white incrustation on the plates may be visible and there will be loss of capacity.

How can such a battery be restored to its normal state?

By cycling. The battery is charged at one-twentieth of its rated 10-hour capacity, and the charge maintained until the specific gravity remains constant over five successive hourly readings. The battery should then be discharged through a lamp load at approximately 4–6 amperes. Immediately the voltage of each cell has fallen to 1·8 volts the same charge should again be applied. When fully charged the battery should again be suitable for further service, though if necessary a further cycle of discharge, and charge may be given.

What precautions should be observed when mixing battery electrolyte?

(1) Never add water to concentrated acid: always add the acid to the water.

(2) Always prepare the electrolyte in a lead-lined, glass, or earthenware vessel: do not use a steel or iron container.

DYNAMOS

Describe some of the faults which you would look for in the event of a failure of the dynamo.

After the cover band on the dynamo has been removed, the brushes and commutator should be examined for:

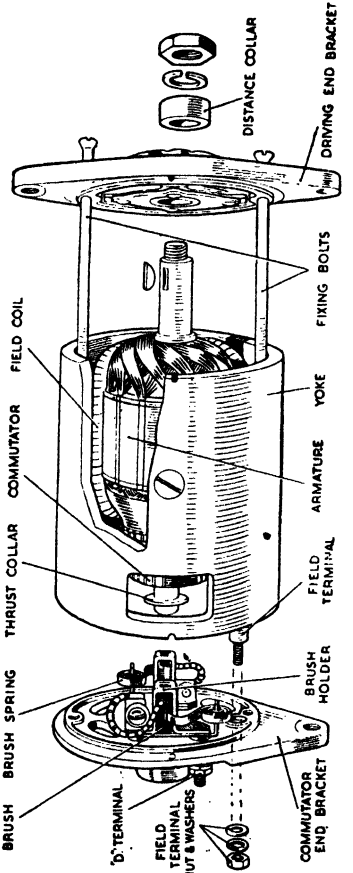


FIG. 19.—EXPLODED VIEW OF LUCAS STANDARD PATTERN CAR GENERATOR.

Broken or disconnected field and brush leads, defective brush springs, or sticking brushes.

Then, while an assistant cranks the engine slowly, look for the following:

(1) Solder blown from the commutator risers.
(2) Burnt or blackened commutators.
(3) Worn brushes.
(4) A flat on one or more commutator bars.
(5) Two commutator bars badly burnt at their adjacent edges.

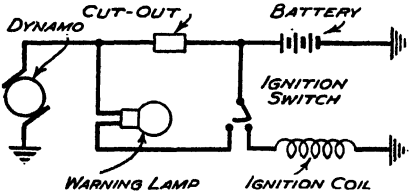


FIG. 20.—CONNECTIONS OF IGNITION WARNING LAMP.

If the ignition warning light remains alight while the engine is running, what trouble is indicated ?

This usually means that the dynamo is not generating; consequently the battery is discharging through the lamp and the armature windings of the dynamo.

A persistent dim light, however, indicates that a voltage exists across the lamp owing to resistance in the cut-out circuit; probably caused by dirty contacts, bad series coil connections, or loose terminals.

What is a frequent cause of a low charging rate ?

A slipping belt drive to the generator.

What is the cause of a slipping belt ?

Worn pulleys, worn or greasy belt, loose mounting.

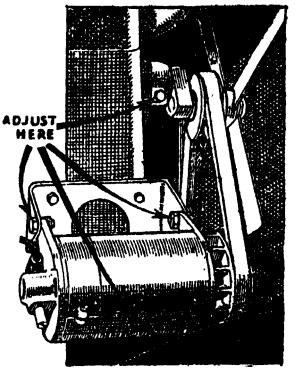


FIG. 21.—GENERATOR DRIVE-BELT ADJUSTMENT POINTS.

Correct tension of the drive belt is obtained when it is just possible to pull round the fan blades by hand.

What are the symptoms denoting an excessive charge rate due to an incorrectly adjusted, or faulty, regulator unit?

Battery requires excessive topping, gases freely, and gives off fumes. Frequent blowing or blackening of bulbs. Constant burning of the ignition contacts.

What are the most likely causes of "no charge"?

(1) Blown dynamo or field fuse. Dynamo not generating or not generating sufficient voltage to close the cut-out contacts.
(2) Cut-out faulty; contacts not closing or dirty.
(3) Regulator faulty; preventing generator voltage from building up.
(4) Broken, dirty, or loose connections in the charging circuit.
(5) Defective ammeter.

What part of the dynamo requires most attention?

The brush gear, because carbon dust collects on and around the commutator and brush-holders, and will eventually cause short-circuited commutator segments or earth the brush gear unless cleaned.

Why is brush bedding important?

Because sparking and overheating of the brushes will occur unless the brush surface is evenly bedded. The

output of the dynamo may alter considerably on a machine with badly bedded brushes as the bedding improves with wear.

How does the grade of brush affect the dynamo ?

Various qualities of brushes have differing resistances, carrying capacities, and abrasive qualities, so that a change in grade may result in excessive wear of the commutator, a different output, and sparking.

What happens when the main brush sticks in the holder ?

Sparking will occur at that point unless the gap is sufficient to entirely break the circuit, in which case the fuse will blow or the dynamo become overheated.

Is the effect the same when the control brush sticks ?

No, sparking will occur, but if the gap is wide enough to disconnect the brush entirely from the commutator the field circuit will be broken and the dynamo will not generate.

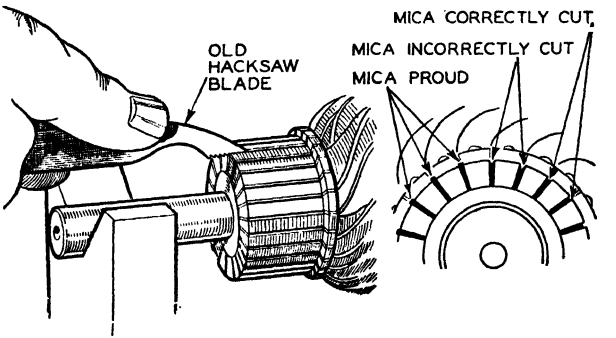


FIG. 22.—HOW THE MICA SEGMENTS OF THE COMMUTATOR ARE UNDERCUT.

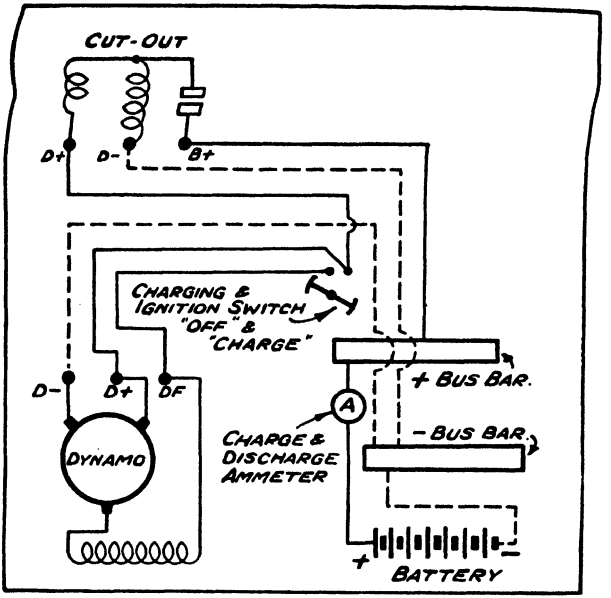


FIG. 23.—CHARGING CIRCUIT.

This shows the main parts of the dynamo and battery circuit including the cut-out.

Why does the commutator mica require to be undercut?

The copper may wear more rapidly than the mica, with the result that the mica will project beyond the face of the copper segments and cause the brushes to be lifted as the armature is revolved. Sparking between the brushes and copper segments is set up and rapid wear of these parts will take place.

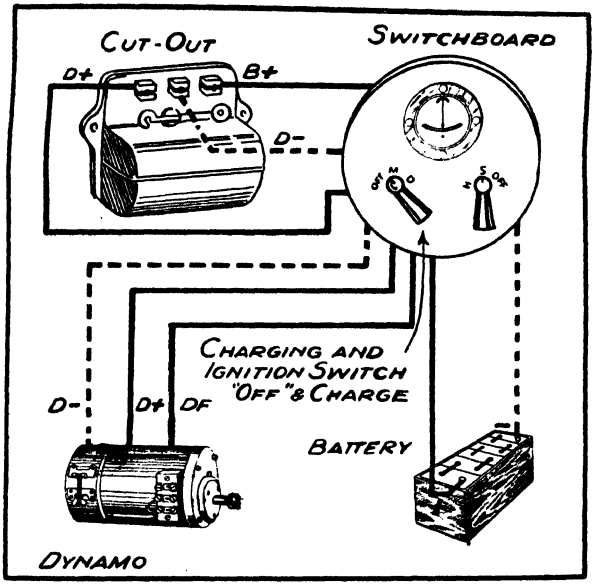


FIG. 24.—PICTORIAL DIAGRAM OF THE CHARGING CIRCUIT.
See Fig. 23.

What is the purpose of the cut-out?

To switch the dynamo into the circuit as soon as its speed is sufficient to enable it to charge the battery, and to disconnect the dynamo whenever it is not generating a voltage sufficiently high to enable it to charge the battery.

Describe the more common types of cut-out faults.

Failure of the contacts to close may be due to incorrect

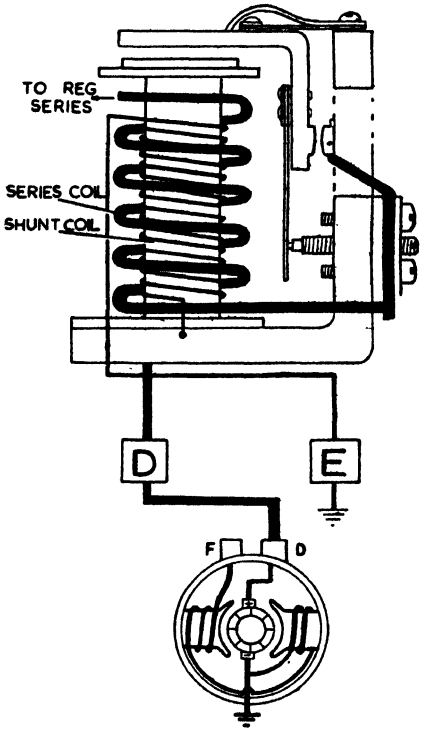


FIG. 25.—THE AUTOMATIC CUT-OUT.

setting of the spring (tension too great), loose or broken connections or a broken shunt winding.

Failure to open may be caused by a reversal of the polarity of the dynamo, maladjustment of the armature/core air gap or high resistance at contacts.

What is the most likely cause of the cut-out contacts chattering ?

Incorrect connection of the cut-out to the dynamo and battery. Other causes may be due to the battery being run down or having the cut-out spring adjustments too slack.

What is the most likely cause for complete failure of the cut-out ?

A break in the shunt coil will cause a complete failure. If there is a break in the series coil, the cut-out contacts will still close at the correct voltage, but no charging current will flow into the battery circuit.

How would you remedy this ?

Repair the break if possible; otherwise rewind the coil, providing the exact size of wire can be obtained. In most cases of this kind it will be found preferable to fit an entirely new cut-out, which can usually be obtained from the makers of the particular electrical equipment.

What is the only adjustment that is normally needed on a cut-out ?

Adjustment of the spring tension on the armature or plate. This spring tends to fatigue.

How are cut-out contact points cleaned ?

Corrosion or dirt may be removed from contact points with spirit or very fine carborundum paper. Do not use a file or any form of coarse grit.

Place the strip between the points, close them by hand and draw the paper through. Repeat this operation two or three times with the rough side towards each contact.

STARTER MOTORS

If the starter motor fails to respond to the starter button, what would be the possible causes?

(1) Battery run down.
(2) Starter button connections faulty.
(3) Broken connections in starter circuit.
(4) Brush and commutator trouble in motor.

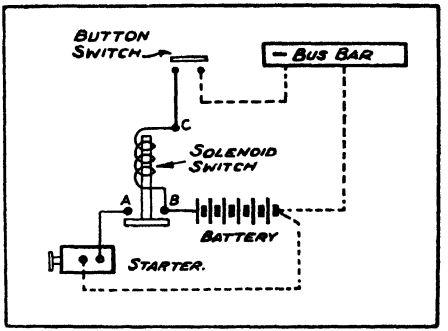


FIG. 26.—REMOTE CONTROL CIRCUIT FOR STARTER MOTOR.

This system is adopted in some cars. The button switch carries only a small current which operates an electro-magnet or solenoid switch which closes the main starter circuit.

What would be the possible reasons for the motor being sluggish or failing to start engine?

(1) Battery partially exhausted.
(2) Loose terminal in starter circuit.
(3) Engine seized.
(4) Engine gummed up.
(5) Brush and commutator trouble.

If the starter is sluggish what is the quickest way of telling whether this is due to the battery?

(1) Switch on headlights.
(2) Stand in front of car.
(3) Ask someone to press starter button.
(4) Observe if lights go very dim when button is pressed; if they do the battery is run down.

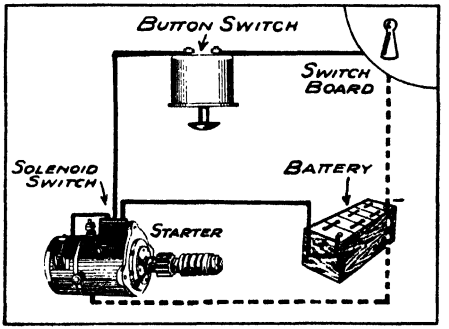


FIG. 27.—PICTORIAL DIAGRAM OF THE REMOTE CONTROL CIRCUIT FOR THE STARTER MOTOR.
See Fig. 26.

What faults cause loss of power in a starter?

Small increases in the resistance of the starter circuit caused by loose or dirty terminals, badly bedded or sticking brushes, dirty commutater, will considerably reduce the power developed by the starter.

What is the cause of a starter pinion jamming in mesh?

Insufficient clearance between the gears, or starter not aligned correctly.

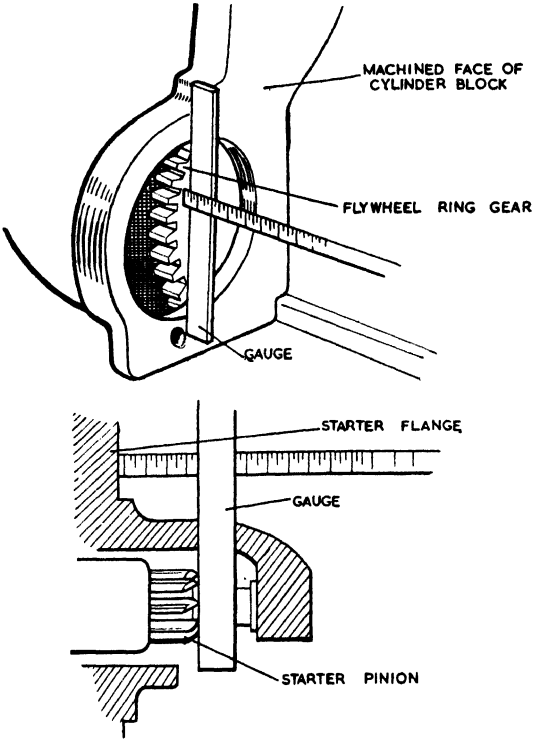


FIG. 28.—CHECKING FOR STARTER-PINION "OUT-OF-MESH" MEASUREMENT USING GAUGES.

The pinion should have just a working clearance from the flywheel ring gear. This clearance should not exceed $\frac{1}{8}$ in.

What will prevent a starter pinion meshing ?

Starter out of alignment or flywheel teeth damaged through incorrect backing off.

What will occasion a loose pinion balance weight ?

A loose mounting with dowel disengaged, allowing the starter to move endwise, so that pinion meshes too deeply and the balance weight knocks against the flywheel.

What is the cause of a broken or strained starter gear spring ?

Engaging the starter whilst the engine is running, or starting up with the ignition too far advanced, resulting in the engine backfiring.

What may cause a starter to seize up ?

A badly bent armature, or oilless bearings gummed up.

When the starter gear does not disengage after the engine starts up what damage will ensue ?

Owing to the very high speed at which the starter armature will be driven, the windings are liable to be "thrown" by centrifugal force and the banding wires broken.

What does heavy sparking at the brushes indicate ?

Loose commutator connections or sticking brushes.

What will cause the starter armature to revolve jerkily and unevenly ?

Broken armature leads or armature fouling the pole pieces.

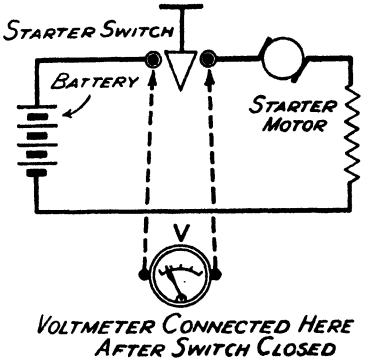


FIG. 29.—METHOD OF TESTING STARTER SWITCH

How is a break in the field circuit indicated?

Usually the field and armature are connected in series so that any break in the field will prevent the starter from operating. Should the field be connected in half parallel the starter will work at reduced power when one side of the field is broken.

What causes burnt contacts?

Slow movement of the operating plunger or insufficient movement. An electric arc is formed between the terminal contacts and the bridge contact, which burns the copper, and which will eventually cause a failure of the switch.

What may cause the starter to continue to run after operating switch is released?

The plunger of the switch is probably sticking, owing to burnt contacts, jammed spring, or press button fouling the dashboard.

How can a starter switch reduce the power of the starter?

Burnt contacts, loose connection between terminals and contact, or between terminals and cable sockets, will increase the resistance of the circuit and cause a drop in voltage at these points, so that the starter energy is reduced.

STARTER MOTOR
FAULT LOCATION TABLE

Condition	*Probable Fault*	*Remedy*
Motor sluggish or fails to move engine.	If engine cannot be turned by hand, then fault is due to a stiff engine.	Locate and remedy cause of stiffness.
	If engine can be turned by hand, then trouble may be due to:	
	Battery discharged.	Start by hand. Charge battery either by a long period of daylight running or from independent electrical supply.
	Broken or loose connection in starter circuit.	See that connections to battery, starter, and starter switch are tight, and that cables connecting these units are in order.
	Starter commutator or brushes dirty.	Clean.
	Brushes worn, not fitted correctly, or wrong type.	Replace worn brushes. See that brushes "bed" correctly.
	Starter pinion jammed in mesh with flywheel.	Rotate squared end of starter shaft with spanner.
Starter operates, but does not crank engine.	Pinion of starter drive does not engage with flywheel due to dirt on screwed sleeve.	Clean sleeve with paraffin and add a few drops of machine oil.
Starter pinion will not disengage from flywheel when engine is running.	Starter pinion jammed in mesh with flywheel.	Rotate squared end of starter shaft with spanner.

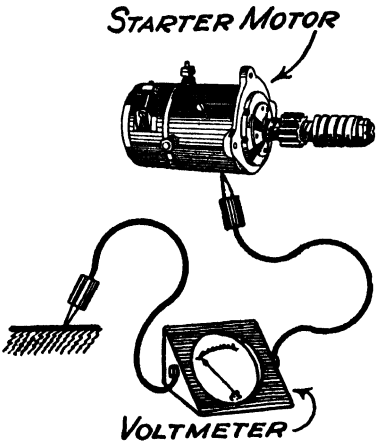


FIG. 30.—TESTING THE STARTER MOTOR FOR A GOOD EARTH CONNECTION.

With the voltmeter prods applied to the motor frame and part of the car frame no appreciable voltage should be registered when the starter button is depressed.

How is a break in the solenoid circuit indicated ?

No current will flow through the solenoid coil, and therefore the main contacts will not be connected and the starter will not operate.

How can the starter motor circuit be distinguished from the remainder of the vehicle's electrical equipment ?

Because the cable used for this circuit is much thicker than that used for other portions of the circuit.

What would be the effect of a "short" in the starter circuit ?

The extremely heavy current flowing would quickly ruin the battery, which would become very hot in the process. The insulation on the wiring might also be charred, and should be replaced when the fault is remedied.

Section 7

TRANSMISSION GEAR

How would you distinguish a transmission fault ?

Where the car stops but the engine keeps running, the fault lies in the transmission between the flywheel and the driving hubs. This includes the clutch and its withdrawal mechanism, the gearbox and its control mechanism, the Cardan shaft and its one or more universal or fabric joints, the differential and the two shafts leading to the rear hubs: only a systematic search, starting from the clutch, will locate the fault which is generally a breakage.

How would you test for excessive wear in the transmission ?

Jack up near side road wheel and measure the amount of free motion of this wheel with the various gears engaged. The free motion should not exceed about 1 in. measured along the circumference of the wheel.

What are the main faults to be met with in clutches ?

(1) Clutch spin; which is due to imperfect disengagement.

(2) Fierceness; which is caused by buckled or scored plates, or misalignment.

(3) Heat; which may be due to broken clutch springs, badly worn linings, or faulty adjustments.

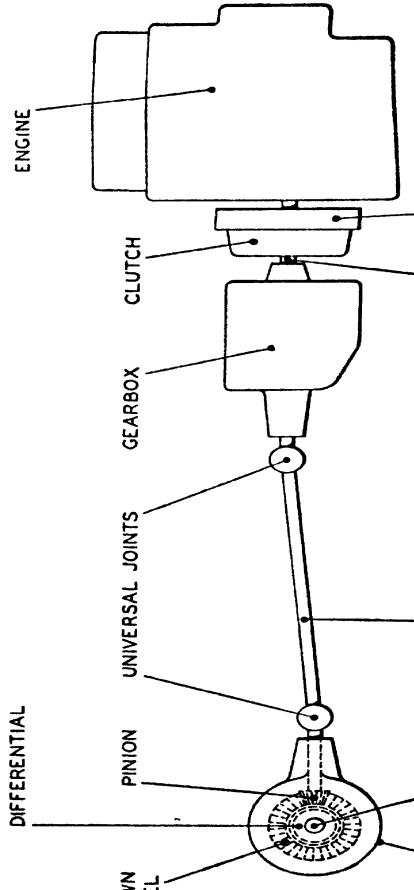


FIG. 31.—GENERAL ARRANGEMENT OF AUTOMOBILE TRANSMISSION SYSTEM.

BORG AND BECK CLUTCHES

What are the possible causes and remedies for drag or spin ?

Cause	*Remedy*
(1) Oil or grease on the driven plate facings.	Fit new facings.
(2) Misalignment between the engine and splined clutch shaft.	Check over and correct the alignment.
(3) Improper pedal adjustment not allowing full movement to release bearing.	Correct pedal adjustment.
(4) Warped or damaged pressure plate or clutch cover.	Renew defective part.
(5) Driven plate hub binding on splined bearing shaft.	Clean up splines and lubricate with small quantity of high melting-point grease.
(6) Pilot bearing or bushing of clutch shaft binding.	Renew or lubricate pilot bearing.
(7) Distorted driven plate due to the weight of the gearbox being allowed to hang in clutch plate during erection.	Fit new driven plate assembly, using a jack to take the over-hanging weight of the gearbox.
(8) Broken facings of driven plate.	Fit new facings.
(9) Dirt or foreign matter in the clutch.	Dismantle clutch from flywheel and clean the unit, ensuring that all working parts are free. *Caution:* Never use petrol or paraffin for cleaning out clutch.

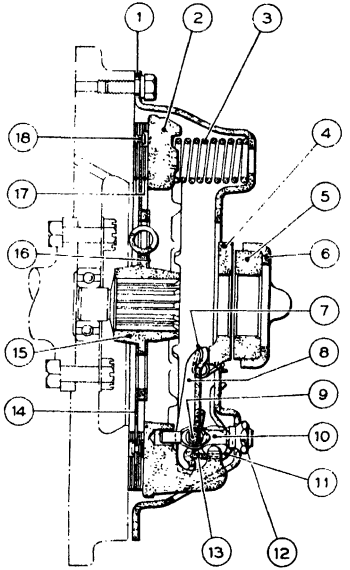


FIG. 32.—TYPICAL BORG AND BECK CLUTCH.

1. Cover; 2. Pressure plate; 3. Thrust springs; 4. Release plate; 5. Graphite release bearing; 6. Release-bearing cup; 7. Retainer springs; 8. Release lever; 9. Floating pin; 10. Eye-bolts; 11. Anti-rattle springs; 12. Adjusting nuts; 13. Strut; 14. Driven-plate disc 15. Splined hub; 16. Disc adapter; 17. Plate facings 18. Facing rivets.

Describe how fierceness or snatch can be overcome.

Cause	*Remedy*
(1) Oil or grease on driven plate facings.	Fit new facings and ensure isolation of clutch from possible ingress of oil or grease.
(2) Misalignment.	Check over and correct the alignment.
(3) Binding of clutch pedal mechanism.	Free and lubricate journals.
(4) Worn-out driven plate facings.	New facing required.

What are the usual causes of slip ?

Cause	*Remedy*
(1) Oil or grease on the driven plate facings.	Fit new facings and eliminate cause of foreign presence.
(2) Binding of clutch pedal mechanism.	Free and lubricate journals.
(3) Improper pedal adjustment indicated by lack of the requisite 1 in. free or unloaded foot pedal movement. Incorrectly replaced floorboards, preventing complete movement of the pedal.	Correct pedal adjustment and/or clearances.

How may judder be caused and cured ?

Cause	*Remedy*
(1) Oil, grease, or foreign matter on the driven plate facings.	Fit new facings and eliminate cause of foreign presence.
(2) Misalignment.	Check over and correct alignment.
(3) Pressure plate out of parallel with flywheel face in excess of the permissible tolerance.	Readjust levers in plane, and if necessary fit new eyebolts.
(4) Contact area of friction facings not evenly distributed. Note that friction facings surface will not show 100 per cent contact until the clutch has been in use for some time, but the contact area actually showing should be evenly distributed round the friction facings.	This may be due to distortion; if so fit new driven plate assembly.

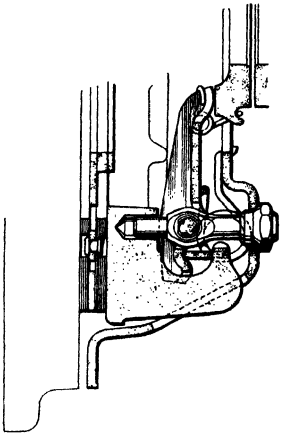


FIG. 33.—POSITION OF RELEASE LEVER WITH CLUTCH ENGAGED.

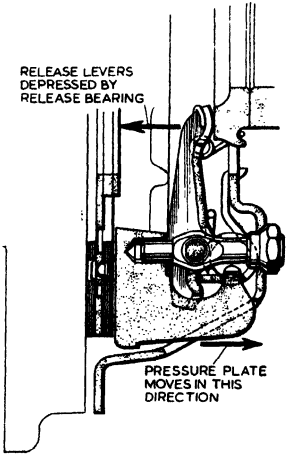


FIG. 34.—POSITION OF RELEASE LEVER WITH CLUTCH DISENGAGED.

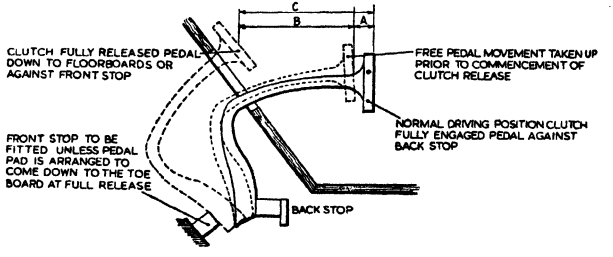


FIG. 35.—CLUTCH-PEDAL TRAVEL ADJUSTMENT.

(5) Bent splined shaft or buckled driven plate.	Fit new shaft or driven plate assembly.
(6) Unstable or ineffective rubber engine mountings.	Replace and ensure elimination of endwise movement of power unit.
(7) Chassis-to-engine tie bar out of alignment.	Correct to ensure that power unit is held against endwise travel.

What are the most likely causes of rattle ?

Cause	*Remedy*
(1) Damaged driven plate, i.e. broken springs, etc.	Fit new parts as necessary.
(2) Worn parts in release mechanism.	
(3) Excessive backlash in transmission.	
(4) Wear in transmission bearings.	
(5) Bent or worn splined shaft.	
(6) Graphite release bearing loose on throw-out fork.	

How may tick or knock be overcome ?

Cause	*Remedy*
(1) Hub splines badly worn due to misalignment.	Check and correct alignment, then fit new driven plate.
(2) Worn pilot bearing.	Pilot bearing should be renewed.

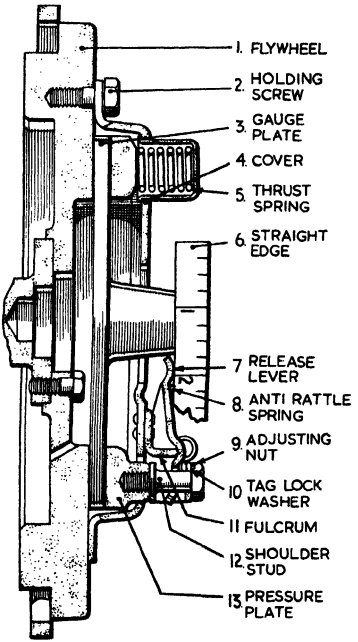
What faults might cause the fracture of the driven plate ?

Cause	*Remedy*
(1) Misalignment distorts the plate and causes it to break or tear round the	Check and correct alignment and introduce new driven plate.

(1 *continued*)
hub or at segment necks in the case of Borglite type.

(2) If the gearbox during assembly be allowed to hang with the shaft in the hub, the driven plate may be distorted, leading to drag, metal fatigue, and breakage.

Fit new driven plate assembly and ensure satisfactory reassembly.



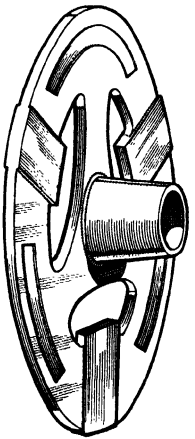


FIG. 36. (*above*)—GAUGE PLATE.

FIG. 37. (*left*)—SETTING RELEASE LEVERS WITH GAUGE PLATE IN POSITION ON 6½-IN. "A"-TYPE CLUTCH.

What indications are given by a worn thrust race which enable you to diagnose the trouble ?

A low rumbling sound when the clutch is withdrawn, coupled with a certain amount of roughness that can be felt on the pedal.

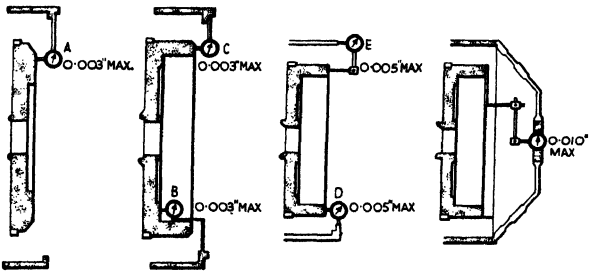


FIG. 38.—METHODS OF CHECKING FLYWHEEL AND HOUSING ALIGNMENT WITH CLOCK INDICATOR.

Mounting (A) shown in diagram (1) for flat flywheels and mounting (B) shown in diagram (2) for recessed type of flywheel are used to determine run-out on friction face of flywheel and should not exceed 0·003 in. Mounting (C) shown in diagram (2) shows correct method of checking rear face of flywheel. Run-out should not exceed 0·003 in. Mounting (D) shown in diagram (3) illustrates method of checking the housing is concentric with the flywheel. Run-out should not exceed 0·005 in. It is also important that the rear face of the engine housing be parallel with the flywheel face, and this run-out as indicated by mounting (E) diagram (3) should not exceed 0·005 in.

With the gearbox case mounted on the engine and the clock mounted on the flywheel as shown in (4) check the hole in which the bearing is mounted. Total variation should not exceed 0·010 in

Why does an insufficient clearance between the pedal and the toeboard cause clutch slip ?

Because the clutch pressure spring is then exerting part of its pressure in keeping the pedal in contact with the toeboard. The greater the pressure against the toeboard the less remains to force the driving and driven

components of the clutch together. Insufficient pressure is therefore left to maintain the components in proper engagement.

What is the usual cause of abnormal facing wear ?

This is usually produced by overloading and by the excessive slip starting associated with overloading.

What produces a reduction of the clearance between the clutch pedal shaft and the toe-board in service ?

Wear of the friction linings which permit the clutch components to take up slightly different positions relative to one another. The difference in position is transmitted to the clutch pedal via the withdrawal mechanism.

GEARBOXES

What are the usual causes of noisy gears ?

(1) With vehicle running:

(*a*) Gears worn.

(*b*) Bearings worn (this may include the mainshaft spigot bush).

(*c*) Insufficient or incorrect lubricant in gearbox.

(*d*) Layshaft bearings worn.

KEY TO FIG. 39 (SEE FACING PAGE)

1. Laygear; 2. Front thrust washer; 3. Third speed wheel, synchronising cone and coupling sleeve, mounted on bush; 4. Second speed wheel, synchronising cone and coupling, mounted on bush; 5. Rear thrust washer (steel); 6. Synchronising springs and balls; 7. Layshaft steel thrust washer (rear); 8. Gearbox case; 9. Gearbox rear cover; 10. Third motion shaft nut; 11.Third motion shaft; 12. Rear oil seal; 13. Speedometer wheel; 14. Rear ball bearing; 15. First speed wheel; 16. First and second speed fork; 17. Top cover setscrews; 18. Top cover; 19. Change speed lever; 20. Change speed lever spring; 21. Reverse fork; 22. Change speed gate with interlock arm; 23. Third and fourth speed fork; 24. sleeve; 27. Front ball bearing; 28. First motion shaft bush; 29. First motion shaft; 30. Ring for first motion shaft; 31. Spring ring for front ball bearing; 32. Front cover; 33. Layshaft or countershaft; 34. Front cover screw.

(2) While vehicle stationary:

(*a*) Constant mesh gears worn.
(*b*) Main drive gear bearings worn.
(*c*) Layshaft bearings worn.

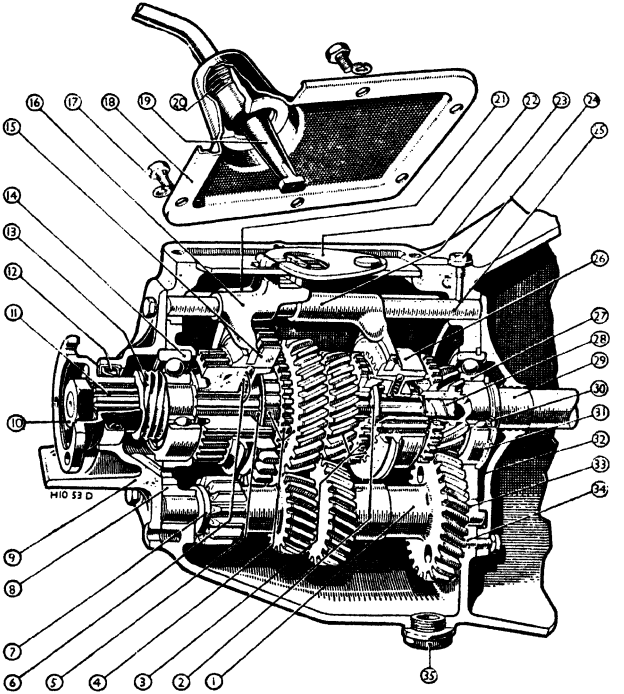


FIG. 39.—SECTIONAL VIEW OF A TYPICAL SYNCHROMESH GEARBOX WITH FOUR SPEEDS FORWARD AND ONE REVERSE.

(See key on page 94) (*Austin Motor Co. Ltd.*)

What may be the cause of gears jumping out ?

(1) Gearbox out of line with crankshaft or distorted.
(2) Worn gears.
(3) Worn selector rods.
(4) Worn selector forks.
(5) Mainshaft worn.
(6) Selector fork ball spring broken or stuck.

How do oil leaks normally occur ?

(1) Bearing baffles not fitted, or fitted incorrectly.
(2) Insufficient radial clearance between the universal joint hub and the rear cover.
(3) Box overfilled with lubricant.
(4) Mainshaft bearing rotating in the gearbox casing.

What faults would you suspect in the case of a seized spigot bush ?

(1) Insufficient lubrication.
(2) Rear bearing outer race retainer out of position.

Should there be any play or "backlash" in the bevel gears when they are properly adjusted ?

Yes, it is essential that a small amount of play should exist in all gear-drives; the amount is regulated by the type of gearing.

What are the chief causes of broken bevel gears ?

Incorrect meshing of gears, gears too deep in mesh is the chief cause, but too far out of mesh will also cause broken teeth. Foreign substances in the axle case, poured in with thick lubricating oil is a frequent cause of damage. The breaking up of a ball or ball race will also cause smashed gears if the pieces get into the teeth. In cars fitted with transmission brakes, too violent application of these will damage the driving gears. Letting the clutch in "with a bang" when car is on a steep hill or on bad ground will frequently damage the bevel gears.

PROPELLER SHAFT AND REAR AXLE

What are the usual causes of propeller shaft transmission vibration and noise ?

(1) Shaft bent.
(2) Loose flange bolts.
(3) Worn needle rollers in universal joint bearing (unlikely to occur except after heavy mileage).
(4) Worn or defective front propeller shaft bearing.

What fault would you look for if the gearbox rear bearing outer retainer was found to be out of position ?

Insufficient lubrication of the propeller shaft splines.

What end play should be allowed when replacing a propeller shaft and what happens if none is allowed ?

From $\frac{1}{8}$ in. to $\frac{3}{8}$ in. is the general amount of end play allowed. If none is allowed, a knock will be set up in the transmission owing to the fact that no allowance is made for the flexing of the springs.

Where are the most likely places for wear to occur in (a) a Cardan joint, (b) a Hooke's joint ?

(*a*) In the Cardan dies and in the pins upon which the dies move.
(*b*) In the fork bushes and on the pins.

What is the best method for extracting a bush, when no hand press is available ?

Obtain a long bolt, with a head slightly larger than the inside diameter of the bush. Pass the bolt through the bush and through a packing piece large enough to allow the extracted bush to pass through it. Fit a nut

and large plain washer on the end of the bolt and tighten up the nut, until it draws the bush out, through the packing piece.

What is the maximum amount of play permissible between the dies and pins in a Cardan joint, and also between the dies and the block ?

There should not be more than 0·01 in. between the dies and the pins, and also between the dies and the block. If more is found, the worn parts should be renewed.

Can the bearings used in back axles be adjusted when worn ?

Several types of bearings are used in back axles, but only the tapered roller type are adjustable for wear. Ball thrust bearings can be adjusted up, but the bearing itself, if worn, cannot be repaired.

Section 8

BRAKES

How would you test the brakes ?

(1) *Stationary test.* (*a*) Jack up the road wheels. Apply brakes gently and rotate each wheel by hand. The resistance to movement should be even. (*b*) Next rotate each wheel by hand with brakes off. Apply brakes suddenly. Then gently release the brakes. Note whether the brake cam lever has any tendency to stick in the "on" position.

(2) *Road test.* Apply brakes suddenly with clutch disengaged. Note the pressure required to apply brakes fully, and listen for squeaking or chattering of the brakes. The car should pull up within a reasonable distance.

What is a reasonable stopping distance ?

This varies according to the speed of the car when the brakes are applied. The table below shows reasonable stopping distances for various speeds.

m.p.h.	*Distance to stop in feet*
20	19·2
30	43
40	76·6
50	119
60	171

The above figures are based on an overall braking efficiency of 70 per cent.

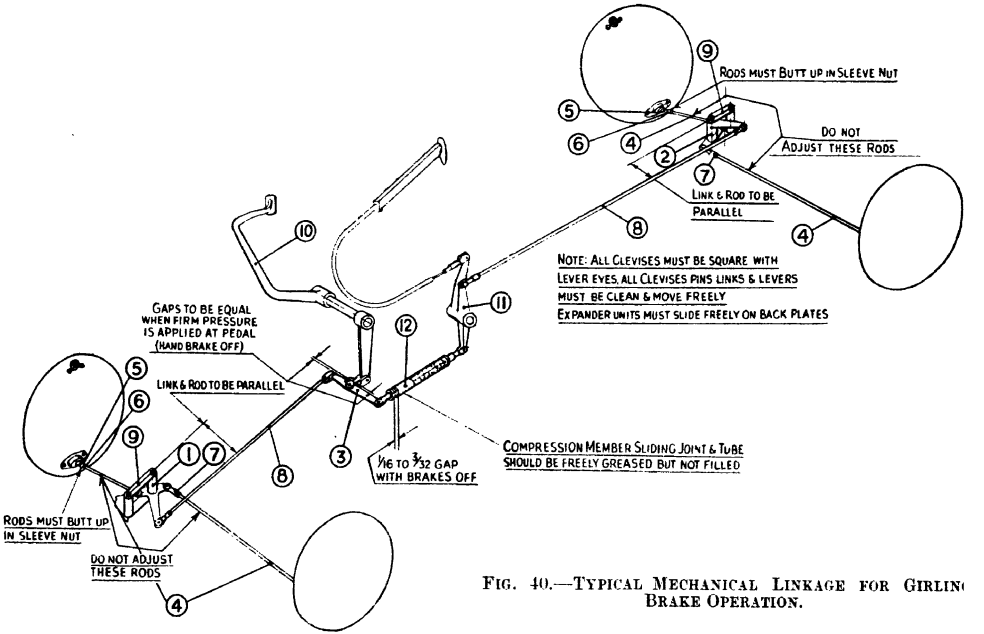


FIG. 40.—TYPICAL MECHANICAL LINKAGE FOR GIRLING BRAKE OPERATION.

Explain in a simple way how to calculate the stopping distance of a car or vehicle.

If a stopping force equal to the weight of the vehicle is applied, this will decrease the speed by 22 m.p.h. for every second the force is in action. In order to obtain this result the brakes would need to be 100 per cent efficient.

A stopping force equal to half the weight of the vehicle will change its speeds by 11 m.p.h. during each second it is in action.

Similarly, a force equal to one-third of the vehicle's weight will change its speed by $22/3 = 7\frac{1}{2}$ m.p.h. every second and so on.

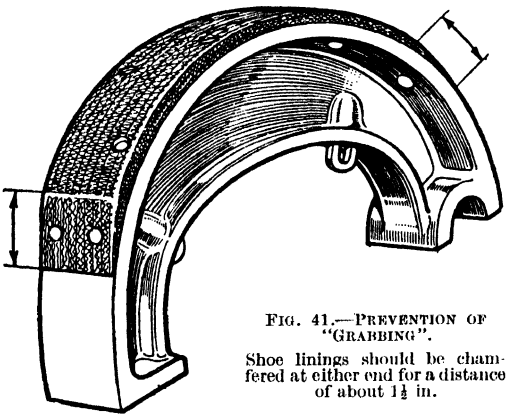


FIG. 41.—PREVENTION OF "GRABBING".

Shoe linings should be chamfered at either end for a distance of about $1\frac{1}{2}$ in.

What is the first step to be taken if the results of the above tests are unsatisfactory ?

Make certain that all components of the brake gear mechanism work freely. Check that all bearings and articulated joints act freely and are well lubricated.

If one or more of the brakes is still unsatisfactory, what is the next step ?

Disconnect the brake lever at the junction to the brake shoe actuating levers. The brake operating mechanism can then be tested independently of the shoe expanding mechanism, and thus further assist in the location of the fault.

What are the causes of poor brake action ?

(1) Oil on the linings.
(2) Worn linings.
(3) Operating levers at wrong angle with pull rods.
(4) Faulty compensation.
(5) Brake drum distortion.

What causes brake "chatter" ?

Brake chatter may be caused by any of the following irregularities, which should be checked in the order given:

(1) Picking up of the brake lining.
(2) Slackness in the shoe pivots.
(3) Burnt oil on linings.
(4) Wear take-off springs.
(5) Damaged brake drums.
(6) Loose brake flange or backplate.
(7) Worn wheel bearings.

What produces uneven brake action ?

(1) Stiffness of one portion of the brake application mechanism due to lack of lubrication.
(2) Faulty individual adjustment.
(3) Faulty functioning or adjustment of compensating device.
(4) Bent levers or brake shafts.
(5) Oil on one of the brake drums.
(6) Lack of rigidity in brake cross-shafts.

How would you rectify a bent cross-shaft ?

Whenever possible the bent cross-shaft should be replaced. If a spare is not available, the shaft should be carefully straightened in a press and tested for freedom of movement.

Describe a frequent cause of brake camshaft stiffness.

This fault may be due to a slightly bent camshaft binding in its bearings, and is most frequently encountered where the camshaft is mounted below the axle. Such camshafts are liable to be bent by the careless placing of a lifting jack.

How would you deal with a complaint of brake squeak ?

First examine all the components to see that they are in proper condition, and make sure that the linings are free from oil or grease. If the brakes are mechanically sound and squeak persists, it should be remedied by the fitting of suitable drum-stiffening bands, preferably of a robust, shrunk-on variety.

How far should the brake pedal travel before the brake is fully applied ?

With the brake gear in good condition a travel of $1\frac{1}{2}$ to 2 in. should be sufficient to apply the brake fully. This represents approximately one-third of the total pedal travel available.

How can excessive brake pedal movement be caused ?

Excessive brake pedal movement in normally operated brakes is due to:

(1) Faulty adjustment.
(2) Wear at the various joints of the braking mechanism.
(3) Brake levers making bad angle with pull rods.

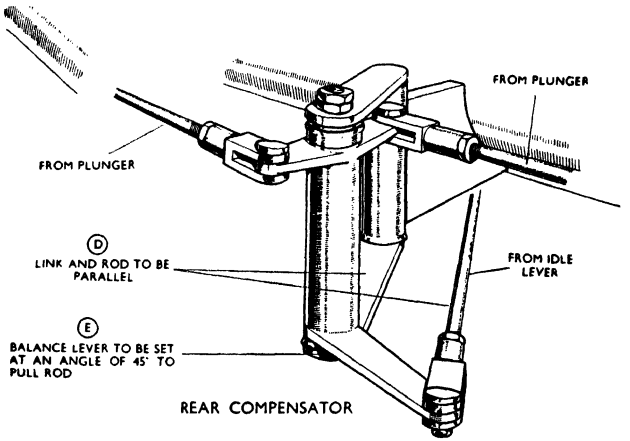


FIG. 42.—SETTING OF REAR COMPENSATOR.

What is the cause of "kick-back" on the brake pedal, often encountered when braking on bad road surfaces?

Incorrect location of the ends of the brake pull-rods, so that there is a considerable divergence between the arcs described by the brake rod and the brake camshaft lever.

What are the two methods of deciding whether brake shoes need to be relined?

If the maker's recommendation is available this provides a reliable guide. In absence of this information, the linings should be renewed before the rivet heads are brought level with the surface. If wear of the lining is allowed to proceed beyond this point, the rivet heads will cause scoring in the inner surface of the brake drum. Linings may sometimes need to be replaced if they have been rendered ineffective through glazing produced by leakage of oil or grease into the brake drums.

What is the probable result of fitting linings which are too long ?

Exceedingly long linings tend to produce brake lining "pick up", and thus "brake chatter".

What is the probable result of fitting linings of incorrect thickness ?

Fitting linings which are too thick will prevent replacement of the brake drum.

Fitting linings which are too thin does not give them a reasonable working life and is largely a waste of time.

What is the method of adjusting brake shoes ?

The vehicle should be jacked up so that all four wheels are off the ground. The brake rod attached to the brake operating arm at the back of each housing plate should be disconnected, and the brake shoe adjusting wedge screwed in as far as possible. This will cause the shoes to bind on the drum when the adjusting wedge can be backed off just sufficiently to permit the wheel to turn freely; the wedge should need no further adjustment apart from screwing in or out one or two notches as may be indicated during a final road test.

What should you particularly look for when examining the various operating rods ?

See whether there are any signs of looseness apparent where the various operating levers are secured to their respective shafts.

If there is looseness of connection between an operating lever and its shaft, how should it be dealt with ?

The securing pin should be drawn out and replaced by a new one—re-riveting of the old pin is very seldom satisfactory. When the pin has been removed, it may sometimes be found that due to this looseness the

FAULT TRACING TABLE

MECHANICAL BRAKES

Fault	*Cause*	*Remedy*
Fails to operate.	Connections broken.	Renew broken member.
	Pedal against toe board.	Adjust movement of pedal or reline brakes.
	Adjusted too far—cam levers so far forward as to lose mechanical advantage.	Brakes probably require relining.
	Brake camshafts jammed.	Ease brake camshaft assembly.
	Seized foot pedal or hand brake lever.	Ease.
Brake does not come off when released.	Main pull-off spring broken or disconnected.	Examine and renew if necessary.
	Pull-off spring in drum broken or disconnected.	Examine and renew if necessary.
	Brake camshafts or foot pedal jammed.	Ease.
	Operating mechanism clogged with dirt.	Clean and grease.
	Lining loose on brake shoe.	Examine and re-rivet if necessary.
Brakes operate unevenly.	Unequally adjusted.	Adjust.
	Part of mechanism clogged.	Clean and grease.
	One or more camshafts jammed.	Examine camshafts and ease.
Brake heavy or hard to operate.	Lack of lubrication.	Grease whole braking system.
	Pins and joints clogged with dirt.	Clean and grease.
	Jammed brake camshafts, etc.	Examine and ease.

pin-hole in the shaft and/or lever has become elongated, in which case one or both of these parts will have to be replaced, as it will be impossible to secure them rigidly together by means of a pin alone. Should, however, the amount of distortion be slight, an oversize pin could be fitted by first positioning the arm on its shaft, and, while being held firmly in this position, a reamer passed through the holes sufficiently large to just make them truly circular. The oversize pin should be large enough to require lightly driving into place before riveting over each end.

LOCKHEED

If when examining a Lockheed brake, it is found that the brake pedal touches the floorboards before the brake is fully applied what is the most likely cause ?

This is usually an indication that the brake shoes require adjustment.

If two or three strokes of the brake pedal are necessary before the brakes come into action, what is the most likely cause ?

This is probably caused by air in the pipe-line.

What is the remedy for air in the pipe-line ?

The bleeding process must be carried out on each brake wheel cylinder.

If repeated pumping with the brake pedal produces no effect at all on the brakes, what does this indicate ?

This is an indication that the supply tank is empty or that a serious leak has developed somewhere in the hydraulic system.

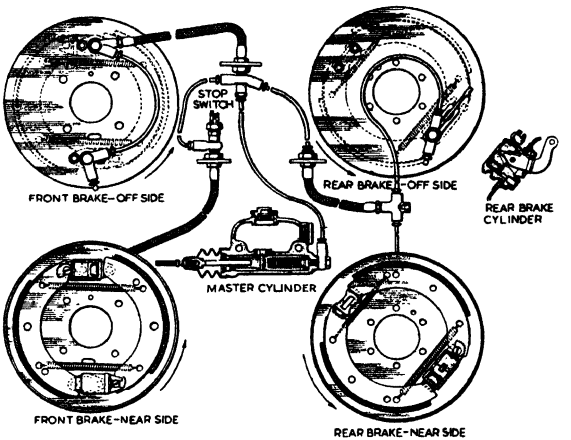


FIG. 43.—DIAGRAMMATIC LAYOUT OF LOCKHEED HYDRAULIC BRAKING SYSTEM FITTED TO CARS AND LIGHT COMMERCIAL VEHICLES.

What steps would you take to remedy the above-mentioned fault ?

First examine the fluid supply and replenish if necessary. If the fault has not been due to lack of fluid, the system must next be examined for indications of leakage. When the leak has been detected and rectified, the supply tank must be filled to the proper level and the system must then be bled at each wheel in the usual way.

If a Lockheed brake pedal moves slowly down when a steady pressure is applied to it, what does this indicate ?

This is an indication that there is a slight leak somewhere in the hydraulic system. The remedy is to locate

the leak and remake the faulty joint, afterwards bleeding the system at each wheel as already described.

If Lockheed brakes are found to be sluggish in coming on when the pedal is depressed, what are the possible causes ?

Sluggish action of Lockheed brakes may be occasioned by any of the following:

(1) Unsuitable fluid in the hydraulic system, e.g. mineral oil instead of Lockheed fluid.
(2) Faulty brake shoe adjustment.
(3) Faulty adjustment of the hand brake.
(4) Brake shoe pull-off springs too weak.
(5) Insufficient pedal clearance.

If you suspect that the wrong fluid has been used in the system, how would you proceed ?

Examine the cup, valve washers, and hoses. If these are sticky or swollen this is almost certainly due to incorrect fluid. The system would then require to be emptied and thoroughly flushed out with Lockheed fluid which must then be discarded. All rubber washers and cups should then be replaced by new ones and as the use of spurious fluid may also damage the hoses, they should be thoroughly examined and renewed if necessary. Finally, after filling the tank with fresh Lockheed fluid, the system should be bled at each brake wheel cylinder.

If you suspect that the brake shoe adjustment is faulty, what would you do ?

Check the clearances between the shoes and the brake drum with the brakes in the "off" position. The shoes should, of course, be free of the drum, but only just sufficiently clear to permit free rotation of the wheel. If the clearance is too great this must be adjusted by means of the hexagon-headed adjusters on the brake backplates.

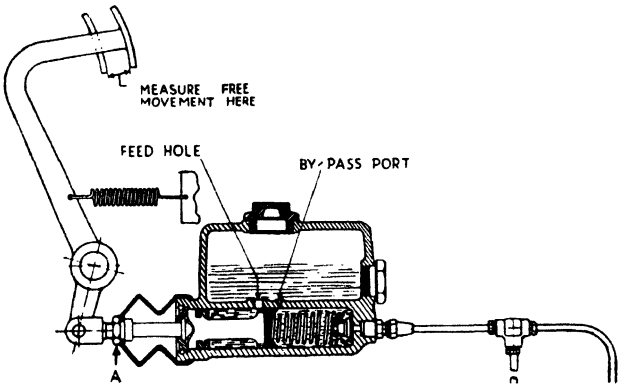


FIG. 44.—BRAKE-PEDAL ADJUSTMENT

A minimum clearance of $\frac{1}{32}$ in. is necessary between the pedal push rod and the master cylinder piston, which entails, with a margin of safety, $\frac{1}{8}$–$\frac{1}{2}$ in. free pedal movement measured at the pedal pad.

How can faulty adjustment of the hand brake cause sluggish operation of the foot brake?

It sometimes happens that although the hydraulic side of the brake system is correctly adjusted, the hand brake has been too liberally dealt with and adjusted too closely, so that the shoes controlled by the hand brake are rubbing slightly. Furthermore, on some cars the hand brake comes on of its own accord when a heavy load is carried. Either cause has the same effect, that of heating the drum and then the wheel cylinders, resulting in excessive expansion of the fluid which may therefore apply the brakes or even cause the fluid to approach boiling-point.

FAULT TRACING TABLE

LOCKHEED BRAKES

Fault	*Cause*	*Remedy*
Excessive pedal travel (requires pumping).	Brake shoes require closer adjustment to the drums.	Adjust accordingly.
	A leakage in the system.	Tighten joints in the line and examine flexible hose.
Pedal feels springy.	The system requires bleeding.	Bleed.
	No fluid in the supply tank.	Replenish.
Inequalities in braking.	The linings are not bedded in.	Rectify.
	Protruding rivets or scored drums.	Rectify.
	Grease on brake linings.	Clean and scrape brake lining and brush with a stiff wire brush.
Poor braking.	Brake shoe linings worn down or soaked in oil.	Reline brake shoes.
	Brakes require adjusting.	Adjust.
Brakes stay "on" or drag when pedal is released.	Brake shoes too closely adjusted.	Slacken off.
	Brake shoes tight on their anchor pins.	Remove shoes and pins and clean.
	Brake shoe return springs weak or broken.	Renew.
	No initial clearance on pedal.	Examine and adjust.
	Master cylinder cup and/or brake expander cups sticking in the cylinder bores, due to the use of unsuitable fluid.	Flush out the system with genuine Lockheed brake fluid and fit new rubber parts.
	Wheel bearings loose.	Adjust or fit new bearings.
Brakes grab or car pulls to one side.	Brake linings not bedded in correctly.	Bed linings to drum and chamfer off the leading ends of leading shoe linings.
	Brake linings dirty or greasy.	Clean linings or reline if necessary.
	Tyres inflated unequally.	Rectify.
	Front spring loose on axle bed.	Tighten and rectify.
	Brake drums distorted.	Remove drums and true-up in lathe.

How would you check that the pedal clearance is correct ?

There should be approximately $\frac{1}{2}$ in. of movement at the tip of the pedal before the master cylinder piston comes into operation.

If the pedal clearance is insufficient what are the possible causes ?

Faulty adjustment of the brake pedal linkage to the master cylinder or, alternatively, a displaced floorboard or mat which prevents the pedal from rising to its full height.

What are the "don'ts" which should be kept in mind when dealing with Lockheed brakes ?

Don't use anything other than Lockheed fluid in the system.

Don't allow grease, paint, oil, or brake fluid to reach the brake linings.

Don't use oil, petrol, or paraffin for cleaning the component parts. Use Lockheed fluid.

Don't reline a shoe or pair of shoes with a different make or quality of lining from that on the other shoes.

Don't forget the push-rod piston clearance.

Don't make the joints in the pipe-lines with the help of jointing compounds. Nothing but straight metal-to-metal joints should be made.

Don't permit the supply tank to be less than half full of brake fluid.

Section 9

STEERING AND TYRES

What information may be needed in order to correct steering troubles ?

(1) Caster.
(2) Camber.
(3) Toe-in.
(4) Pivot-pin or king-pin inclination.
(5) Steering geometry.

What is the caster angle ?

Caster is the amount in degrees of the correct backward tilt of the axle and king-pin. A car without caster lacks steering stability, while unequal caster is denoted by a tendency of the car to pull to the right or left.

What is camber ?

The amount, measured in inches or degrees, that the front wheel should be tilted outwards at the top.

What is toe-in ?

The difference, measured in inches, of the distance between the front wheels at their front and their back. Toe-in is directly related to camber, and where the maximum amount of camber is used, the maximum toe-in must also be used.

What is king-pin inclination ?

This is the amount in degrees that the tops of the king-pins are inclined towards the centre of the car.

What is steering geometry ?

Steering geometry is the mechanics of keeping the front wheels in correct alignment as the wheels are turned

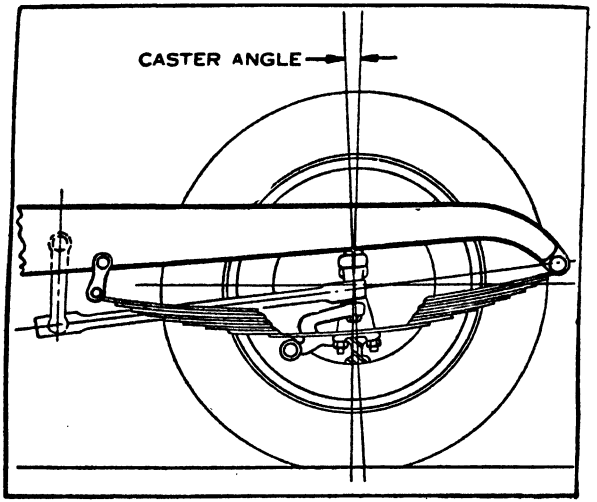


FIG. 45.—CASTER ANGLE.
The amount in degrees of the backward tilt of the axle and king-pin.

to the right or left: it is necessary for the wheels to assume a toed-out position when rounding corners.

What is a frequent cause of wheel bounce ?

The most frequent cause of wheel bounce is lack of wheel balance which may also contribute to other steering troubles.

What are the more common shock-absorber faults that may interfere with steering ?

Insufficient fluid, incorrect operation of valves, or damaged parts.

What are the effects of too much camber ?

The wheel is tilted too far out at the top and the tyre is forced by road contact into a conical shape on its

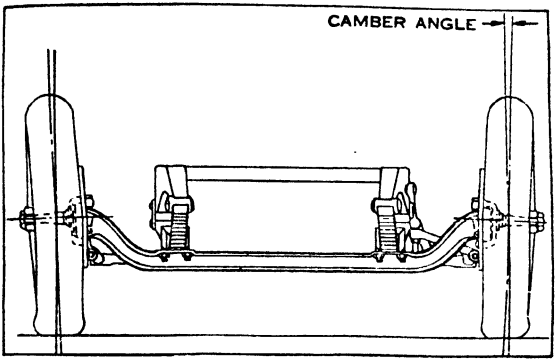


FIG. 46.—CAMBER.

The amount in inches or degrees that the front wheels are tilted outward at the top.

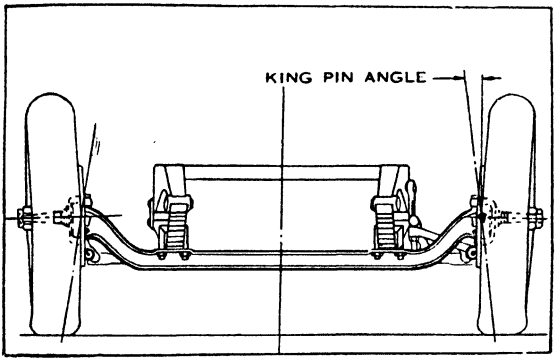


FIG. 47.—KING-PIN INCLINATION.

The amount in degrees that the tops of the king-pins are inclined toward the centre of the car.

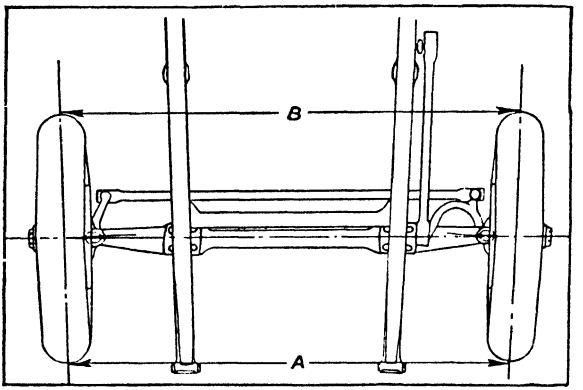


FIG. 48.—TOE-IN.

The amount by which the front wheels are set closer at the front (A) than at the rear (B) when the wheels are in the straight-ahead position.

underside. The result would be excessive tyre wear on the outer edges of the tread.

What is meant by reverse camber and what are its effects ?

A wheel tilted too far in at the top is said to have reverse camber. Reverse camber results in excessive tyre wear on the inner edges of the tread, leaving the centre of the tread comparatively unworn.

Is there any rule governing the camber angle ?

Yes, the rule is that if the wheels have the maximum allowable camber, they must have the maximum amount of allowable toe-in.

How many points are there in a steering gear where wear may take place ?

Nine, these are as follows: the road wheel bearings, the pivot of the stub axle, the pins and bushes of the tie-rod,

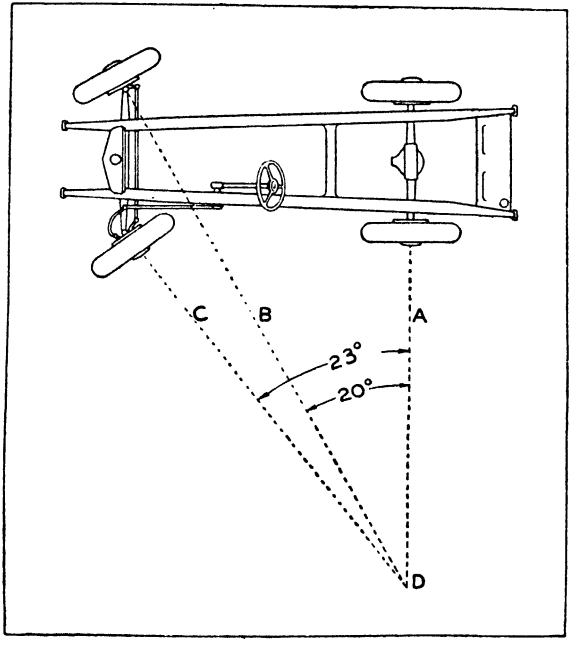


FIG. 49.—TOE-OUT ON CURVES.

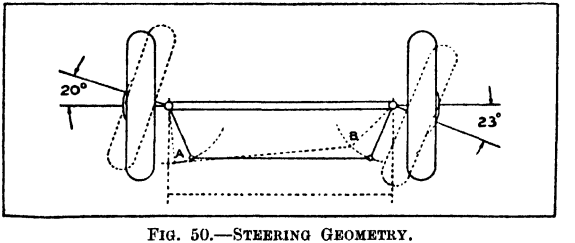


FIG. 50.—STEERING GEOMETRY.

the joints at the two ends of the drag link, the steering gear itself, slackness between gearbox and chassis, shackles of the front springs, the thrust bearings of the steering column, and in the bushes of the worm wheel or its equivalent.

What is the principal point to bear in mind when removing or fitting ball bearings ?

That no hammer or percussive tool must be used.

What is the peculiar difficulty arising when wear occurs in a steering pivot ?

That it is rarely possible to machine the old parts in such a way as to take up the wear. New pivots, pins, and bushes are generally necessary.

What causes steering wobble ?

(1) Wear or broken springs in the steering mechanism.
(2) Weak front laminated springs.
(3) Bad alignment of wheels.

If you found play in the steering wheel, what would this indicate ?

If the play did not exceed $1\frac{1}{2}$ in. measured along the circumference of the steering wheel, it would show that the steering mechanism as far as the coupling rods was in reasonably good condition.

If the play exceeded 2 in. this would indicate either loose joints in the mechanism or else excessive wear in the steering box.

How would you detect backlash in coupling rod joints of the steering gear ?

Jack up the offside front wheel and note the increased play in the steering wheel as compared to the play when both front wheels are resting on the ground.

How would you test for buckled wheels ?

Jack up each wheel in turn, hold a pencil near the rim of the wheel on a steady support and spin the wheel round, any unevenness in the rim can be readily detected in this way.

What are the principal causes of the vehicle pulling to one side ?

Cause	*Remedy*
(1) Low or uneven tyre pressure.	Inflate tyres to proper pressure.
(2) Rear wheels not tracking with front wheels.	Check alignment of rear wheels with front wheels and correct as necessary.
(3) Brakes incorrectly or unevenly adjusted.	Adjust brakes.
(4) Oil-soaked linings.	Replace linings.
(5) Shock absorbers incorrectly or unevenly adjusted, improperly lubricated, or inoperative.	Check adjustment and correct as necessary. Also make sure they are properly lubricated.
(6) Wheel bearings adjusted too tight.	Check for binding with front wheels off floor. Adjust bearings and lubricate.
(7) Toe-in incorrect.	Adjust tie-rods to make front wheels toe-in proper amount.
(8) Incorrect or uneven caster.	Check caster and adjust as necessary.
(9) Incorrect or uneven camber.	Check camber and correct by adjustment or replacing parts.
(10) Front springs sagged.	Check springs. Sagged springs should be repaired or replaced with new ones.
(11) Rear axle shifted. (Spring-clip bolts loose or centre bolt sheared.)	Check spring clips for looseness. Also measure from rear spring bolt to

(11 *continued*)	axle housing. This distance should be uniform on both sides of car.
(12) Frame bent or broken.	Check frame for proper alignment, and breakage. Repair or replace frame as necessary.
(13) Stub-axle knuckle bent.	Replace with new knuckle.
(14) Steering arm bent.	Check by testing toe-out. Replace with new arm.

What faults do cupped tyres indicate ?

Cause	*Remedy*
(1) Tyres improperly inflated.	Inflate tyres to proper pressure.
(2) Normal cupping of tyres.	Explain to owner that such cupping is due to normal action of non-skid tyres on the road.
(3) Wheels, tyres, or brake drums out of balance.	Balance wheels and tyres. Also check eccentric or bulged tyres and replace as necessary.
(4) Dragging brakes. (Incorrectly adjusted.)	Adjust brakes.
(5) Worn stub-axle knuckle bearings, or wheel bearings incorrectly adjusted or worn.	Adjust or replace parts as necessary.
(6) Uneven caster.	Check caster and adjust as necessary.
(7) Stub-axle knuckle bent.	Replace with new stub axle.

How would you deal with scuffed tyres ?

Cause	*Remedy*
(1) Tyres improperly inflated.	Inflate tyres to proper pressure.

(2) Toe-in incorrect.	Adjust tie-rods to make front wheels toe-in proper amount.
(3) Wheels or tyres out of true.	Check for wheel and tyre wobble. See that wheels and tyres are properly mounted.
(4) Stub-axle knuckle bearings worn.	Install new bearings.
(5) Uneven caster.	Check caster and adjust as necessary.
(6) Incorrect toe-out on turns.	Replace steering arms with new ones.
(7) Front axle or suspension arms bent or twisted.	Check wheel alignment by testing camber, king-pin inclination, and caster. Correct front axle or independent suspension arms. Replace arms with new ones.
(8) Stub-axle knuckle bent.	Replace with new stub axle.
(9) Excessive speeds on turns.	Caution driver.

What are the usual causes of "wandering"?

Cause	*Remedy*
(1) Low or uneven tyre pressure.	Inflate tyres to proper pressure.
(2) Steering gear or connections adjusted too loose or worn.	Adjust or install new parts as necessary.
(3) Steering gear or connections adjusted too tight.	Test steering system for binding with front wheels off floor. Adjust as necessary and lubricate.
(4) Stub-axle knuckle bearings worn.	Install new bearings.

Describe how front wheel shimmy can be caused.

Cause	*Remedy*
(1) Low or uneven tyre pressure.	Inflate tyres to proper pressure.
(2) Steering connections incorrectly adjusted or worn.	Adjust or install new parts as necessary.
(3) Steering gear incorrectly adjusted.	Adjust steering gear.
(4) Front wheel bearings incorrectly adjusted or worn.	Adjust bearings or replace with new parts as necessary.
(5) Wheels, tyres, or brake drums out of balance.	Balance wheels and tyres. Also check for out-of-balance brake drums and for eccentric or bulged tyres, and replace as necessary.
(6) Wheels or tyres out of true.	Check for wheel and tyre wobble. See that wheels and tyres are properly mounted.
(7) Incorrect or uneven caster.	Check caster and adjust as necessary.
(8) Shock absorbers incorrectly or unevenly adjusted, improperly lubricated, or inoperative.	Check adjustment and correct as necessary. Also make sure they are lubricated.
(9) Stub-axle knuckle bearings worn.	Install new bearings.
(10) Toe-in incorrect.	Adjust tie-rods to make front wheel toe-in proper amount.
(11) Stub-axle knuckle bent.	Replace with new stub axle.
(12) Insufficient or incorrect lubricant used.	Check lubricant in steering gear and lubricate steering system as required.

(13) Eccentric or bulged tyres.	Replace with new ones.
(14) Stabiliser inoperative.	Inspect bearings and links, replacing worn parts.

What faults would you look for if there is front or rear wheel bouncing of wheels with a tendency for the wheels to be turned in each direction as the wheels move up and down?

Cause	*Remedy*
(1) Wheels, tyres, or brake drums out of balance.	Balance wheels and tyres. Also check for out-of-balance brake drums and for eccentric or bulged tyres, and replace as necessary.
(2) Front springs weak.	Replace or repair springs.
(3) Shock absorbers incorrectly or unevenly adjusted, improperly lubricated, or inoperative.	Check adjustment and correct as necessary. Also make sure they are properly lubricated.
(4) Lubrication needed.	Lubricate chassis.
(5) Stabiliser inoperative.	Inspect bearings and links, replacing worn parts.

What precautions should be taken to ensure that the maximum useful life is obtained from tyres?

(1) Maintain correct tyre pressures, checking all tyres at least once a week, so that they are kept within 5 per cent of recommended values.
(2) Drive carefully, avoiding rapid acceleration, fierce braking, turning at high speeds, kerbstones, etc.
(3) Remove sharp stones, etc., that may have become embedded in the tyres, repairing any damage promptly.
(4) Change round the wheels periodically to ensure that the wear on all tyres, including the spare, is equalised.

(5) Do not allow tyres to come into contact with oil or paraffin.
(6) Maintain correct wheel alignment, and ensure that the brakes are in good adjustment.
(7) Have tyres remoulded in good time.
(8) Punctures or other damage should be vulcanised, patches being used only for emergencies and never for synthetic tubes.

How is the balance of wheels assured with modern tyres?

Balanced wheels facilitate good steering. Manufacturers now mark tyres with a white spot or spots, close to the bead, at the lightest point of the cover while inner tubes are marked with a group of coloured spots to indicate their heaviest point. When the tyres are assembled, these two sets of spots should coincide.

Special balancing discs are occasionally fitted to the inside casing of the cover, and should never be removed.

What is vulcanising?

In repairing serious cuts in outer covers and also in many tube repairs a special compound of rubber containing a proportion of sulphur is filled in the cut and heat is applied by means of a vulcanising kettle. The heat converts the rubber compound into a kind of flexible vulcanite—hence the term "vulcanising".

Can vulcanising be carried out in a small or private garage?

Yes, low temperature vulcanising can be done without any elaborate equipment. High temperature vulcanising work such as retreading can only be handled by an expert with special equipment.

When a tyre valve is being reseated should it be removed from the tube?

No, it should be pushed into the tube and worked along inside until it can be drawn through the new valve hole.

Section 10

LIGHTING AND ACCESSORIES

Describe a quick checkover procedure for car wiring equipment.

(1) Switch on the headlamps.
(2) With lights on ask an assistant to press the starter button. Any dimming of the lights should disappear as soon as the starter button is released. This test will indicate faults in the battery, self-starter, or lighting equipment.
(3) Test each plug for spark by means of a screwdriver with engine running.
(4) Move the ignition control lever (if fitted) and note whether the engine responds.
(5) Set switch to "Charge" or "Dynamo", and note whether the ammeter reading is steady when the engine is running at about normal speed. Any flickering of the needle would indicate defect in dynamo. Now throttle down the engine until it is just ticking over. The ammeter should then read "zero".
(6) Test the traffic indicators for correct operation.
(7) Check dashboard lighting.
(8) Observe petrol gauge (if fitted) for correct functioning.
(9) Switch on interior lighting to ensure that all bulbs are sound.

How would you check the alignment of a car's headlamps ?

With the car standing approximately 25 ft. in front of a wall, the horizontal and vertical lines of the areas of illumination should correspond with the height of the centres of the headlamps from the ground and with the distance between them.

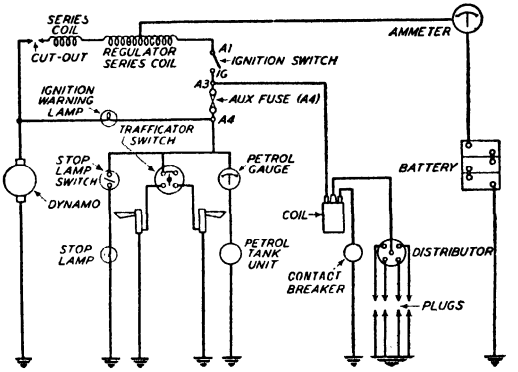


FIG. 51. (*above*)—ACCESSORIES CONNECTED VIA THE IGNITION SWITCH ON TYPICAL C.V.C. SYSTEM.

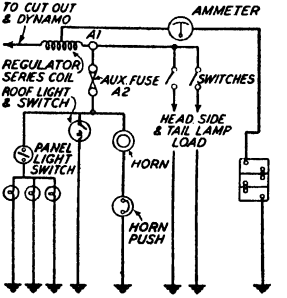


FIG. 52. (*right*)—LIGHTING AND ACCESSORIES CONNECTED VIA THE AMMETER ON TYPICAL C.V.C. SYSTEM.

What are the most likely causes of a lamp failing to light?

(1) Bulb needs renewing.

(2) On earth return system—a defective earth connection.

(3) A faulty lamp holder.

What are the faults which might cause a dipper fuse to blow ?

(1) Wrong rating of fuse.
(2) High-resistance coil short-circuited.
(3) Reflection sticking, possibly as the result of insufficient lubrication.
(4) Contacts out of adjustment.
(5) Solenoid plunger sticking.

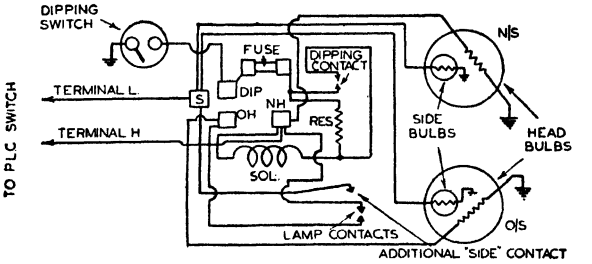


FIG. 53.—CIRCUIT FOR COMBINED HEAD- AND SIDE-LAMPS WITH DIPPING REFLECTOR (THREE-LAMP SET).

An additional contact is required on the dipper unit to maintain the offside side-lamp when the dipper is in use.

What faults may cause the dipping reflector to chatter ?

(1) Battery running down.
(2) Open-circuited resistance.
(3) Dirty contacts.
(4) Faulty earthing connection.
(5) Incorrect contact adjustment. (Gap between switch contacts should usually be between 0·010 and 0·018 in. with the plunger drawn fully into the solenoid.)

When replacing bulbs what legal requirements should be considered ?

(1) All bulbs used for the purpose of showing white lights to the front of the vehicle must have the wattage indelibly marked on the cap or the glass so as to be readily legible.

(2) Bulbs fitted to side-lamps (or used as pilot lights) must not exceed 7 watts. Where two or more bulbs are fitted to the same lamp and are capable of being illuminated at the same time, the total power of such bulbs must not exceed 7 watts.

What accessories are legally necessary ?

Every vehicle must carry an instrument capable of giving audible warning of its approach or position: the use of bells or sirens is restricted to police vehicles, fire brigade vehicles, and ambulances.

An efficient automatic windscreen wiper must be fitted to all vehicles which have the windscreen fitted in such a manner as to be incapable of being opened or otherwise permitting the driver to obtain an unobstructed view of the road.

All motor vehicles (excluding road rollers) must be equipped with a reflecting mirror fitted in a position to enable the driver to be aware of the presence of other vehicles to his rear. A three-wheeled vehicle is regarded as a motor-cycle combination, and a rear-view mirror is not compulsory on such vehicles.

What are the points to be noted when installing and tracing faults on electric horns ?

Avoid disturbing the horn adjustment until it has been ascertained that the unsatisfactory performance is not due to voltage drop caused by the resistance of oxidised push contacts, defective wiring or connections, or a weak battery. Test the horn by connecting it in an independent circuit, or—better still—connect an accurate voltmeter across the horn terminals and note the reading when the horn is sounded.

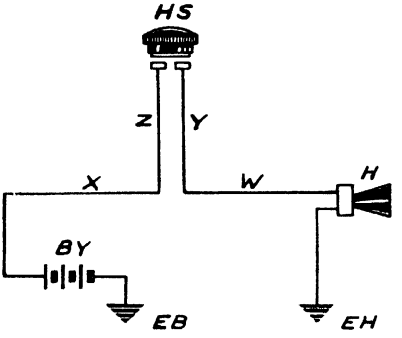


FIG. 54.—ELECTRIC HORN CIRCUIT (SINGLE-POLE SYSTEM).

A strident, ill-tuned note may be due to a maladjusted regulator resulting in an overcharged battery. Modern H.F.-type horns are sensitive to voltage variation and a check is always advisable.

Twin horns, operated through a relay, should be wired direct from the battery terminal of the starter switch, or other convenient main terminal. Most relay units incorporate a fuse, where this is not so a separate fuse-holder should be fitted.

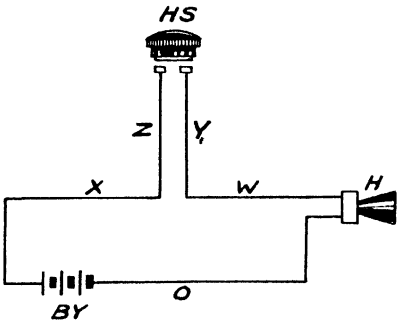


FIG. 55.—ELECTRIC HORN CIRCUIT (DOUBLE-POLE SYSTEM).

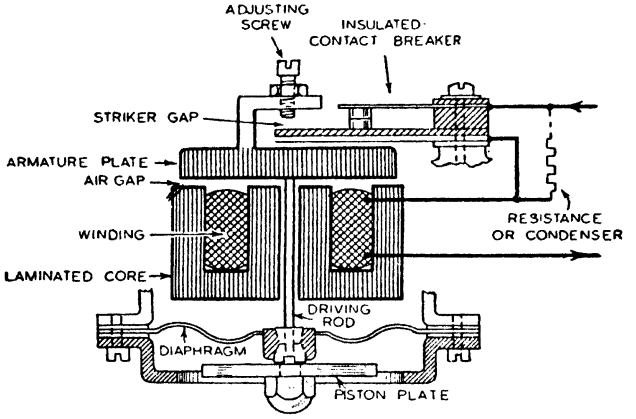


FIG. 56.—HIGH-FREQUENCY HORN.

Where twin horns are wired direct to the battery voltage supply, it is advisable to see that auxiliary fuses are not overloaded. The horns can be wired to separate auxiliary fuses in order to divide the additional load, using a common push-button and return wiring, provided that the two fuses are supplied from a common battery point.

What is the most likely cause of a horn refusing to operate?

The wiring has been disconnected at one of the terminals.

If the horn still sounds, but the note is feeble, what is the probable cause?

Dirty armature or faulty adjustment.

If the horn will not respond to adjustment and gives only a reedy or, at the best, a rattling note, what fault may this indicate ?

The diaphragm may be cracked.

What type of fault results in the constant sounding of the horn ?

The push-button is usually in the earth side of the circuit, so that a short-circuit to earth in any part of this section will result in the horn sounding until the fuse is withdrawn or the ignition switched off.

What fault may cause the fuse to blow ?

A short-circuit in the feed section to the horn. The circuits of the horn itself must be insulated from earth.

What fault would you suspect if there were a single "clack" on making contact ?

This indicates that the armature is striking the magnet-pole face: should the condition not be corrected by turning the adjustment screw clockwise, then the probable fault is either shorted contacts or an earthed winding.

What are the usual causes of an inoperative windscreen wiper motor ?

Faulty switch, dirty switch contacts, or broken connections.

What is the most likely cause of sluggish operation on the part of a newly fitted windscreen wiper ?

The shaft of the wiper is binding on some portion of the screen.

What types of faults may occur on windscreen wiper switches ?

Dirty contacts or a bent cover. Dirty contacts should be cleaned with very fine emery cloth.

What are the causes of a sluggish windscreen wiper motor ?

This is generally due to dried-up bearings, caused by insufficient lubrication. All moving parts should be oiled periodically, and the gearbox kept partly filled with high melting-point grease.

Another cause of slow running is worn-out or sticking brushes. Brushes should be renewed when they no longer make firm contact with the commutator.

How can dirty commutators be cleaned ?

By holding very fine sandpaper on its surface while rotating the armature by hand.

How can sticking brushes be eased ?

By cleaning them with a cloth and a few drops of petrol.

Describe a frequent cause of burnt-out motors.

This may be due to neglecting to switch off the wiper after it has stopped raining. The increased friction between the squeegee and the screen may stall the motor without the driver being aware of it.

What precaution should you take when testing windscreen wipers ?

Do not run the wiper on a dry screen. Wet the screen thoroughly before testing.

LIGHTING FAULT TRACING TABLE

Symptoms	*Probable Fault*	*Remedy*
Lamps give insufficient illumination.	Battery discharged.	Charge battery either by a long period of daytime running or from an independent charging system.
	Lamps out of alignment, or bulbs out of focus.	Align lamps and focus bulb.
	Bulbs discoloured through use of dirty reflectors.	Fit new bulbs or clean reflectors.
Lamps light when switched on, but gradually fade out.	Battery discharged.	As above.
Brilliance varies with speed of car.	Battery discharged.	As above.
Lights flicker.	Battery connection loose or broken.	Tighten connections, or renew faulty cables.
	Loose connection.	Locate loose connections and tighten.
Failure of lights.	Fuse blown.	Examine wiring for faulty cables and remedy. Fit replacement fuse.
	Battery discharged.	As above.
	Loose or broken connection.	Locate and tighten loose connection, or re-make broken connection.

What type of faults are most likely to occur in an electric clock?

Where the clock refuses to operate, the first test should be to ascertain that the external wiring is correct, and that the battery voltage is reaching the clock terminals.

After this has been checked, the clock should be removed from the dashboard and the back detached. Major faults such as a broken ring spring will then be obvious. The internal circuit is easily traced and can be tested by means of a suitable test-lamp or voltmeter. This test should show whether the circuit of the electro-magnetic coils is complete. The slightest dirt on the contact faces is sufficient to cause a failure of this circuit, though in normal circumstances, it should be impossible for dirt to reach this point.

The drying up of the moving parts will impose enough friction to cause sluggish working or stop the clock. Parts working face to face should be very slightly oiled with watch oil (no other type should ever be used) applied by means of a sharp-pointed match-stick.

Other repairs will generally require specialist attention.

Section 11

WIRING FAULTS

What are the two kinds of faults which may occur in the wiring of a vehicle ?

(1) Short-circuit or "earth".
(2) Open circuit.

How are short-circuits indicated ?

Most short-circuit faults in wiring and units are indicated by a blown fuse in the circuit affected. A short-circuit across the terminals of a consuming unit will not blow the fuse until its switch is closed.

When no fuse is fitted in a circuit, how will a "short" be indicated ?

Overheating of the wires and insulation may occur owing to the passage of the short-circuit current. The amount of heating depends on the mechanical cause and the added conductivity in the circuit. A damp insulator surface, for example, might pass a few micro-amperes

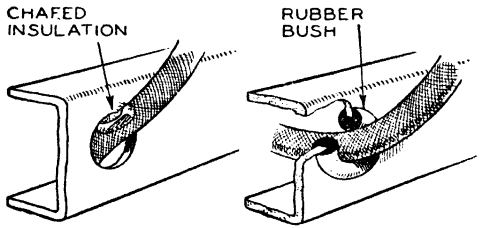


FIG. 57.—A COMMON WIRING FAULT AND ITS CURE.

and so have no apparent effect, but a direct metallic contact across the battery terminals would pass a current of several hundred amperes.

What other kinds of short-circuit are not indicated by a blown fuse ?

(1) A "high resistance" short-circuit, which passes insufficient current to blow the fuse in the circuit, will cause continuous battery discharge.

(2) A "short" across switch terminals which causes the unit in the circuit to operate whether the switch is on or off, but as the resistance of the unit is in series with the fault, no excessive current will flow.

What should you do if a fuse blows ?

The fault in the wiring or unit should be remedied before the fuse is replaced.

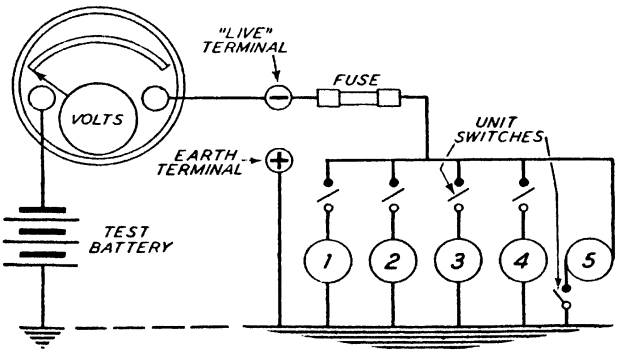


FIG. 58.—LOCATING A SHORT-CIRCUIT USING A VOLTMETER AS A CURRENT-LIMITED AMMETER.

What are the most likely places for wiring faults ?

(1) At terminals, especially battery terminals.
(2) At soldered joints.
(3) At earth connections.
(4) At a tight bight which may chafe.
(5) At a slack bight which can sway.
(6) Wherever a lead may become oily or heated.
(7) Under mudguards.

Describe one method of dealing with a "short"

A smell of burning rubber may be noticed. Feel the outsides of any wires which can easily be reached. If insulation of one cable is perceptibly warmer than the rest the wire should be traced back until the short-circuit is found.

What is the best instrument to use for short-circuit fault location ?

A good voltmeter used as a current-limited ammeter by connecting it in series with the circuit. A test lamp may be used, but is not so satisfactory, since it will not detect a high resistance, or partial short-circuit so easily.

How can a short-circuit in wiring be located by using a voltmeter ?

The illustration shows the method. The test circuit is shown connected to the common terminals of a number of accessory circuits protected by a single fuse, all switches being off. The meter may be connected across the fuse clips in place of a fuse. If a short exists which is unaffected by the switches, it must be situated at some point on the live side of the switches, and the voltmeter will read a value closely approximating to the applied battery volts. If the lines in parallel with the supply are disconnected, one by one, until the reading falls to zero, it is obvious that the last line disconnected carries the fault.

Reconnect this cable to fuse box terminal and disconnect it at the switch. If the reading continues, work back along the cable, disconnecting it at any terminals it may be looped into on the way. Inspect the faulty section for insulation damage which allows the conductor to touch earthed metal. When the fault is disturbed, the reading falls to zero.

On the other hand, if the disconnection at the switch clears the fault, the cable is sound, and the switch terminal insulation to earth is faulty.

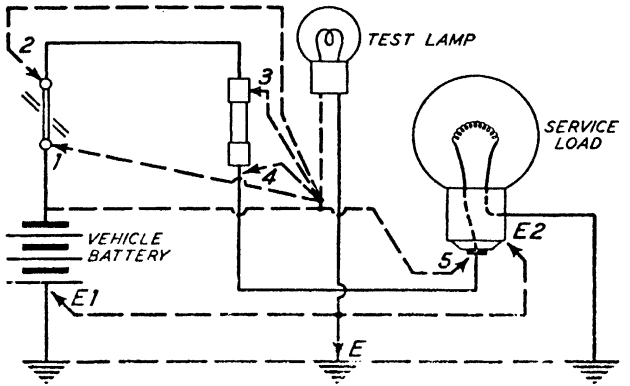


FIG. 59.—TESTING FOR OPEN-CIRCUIT.

How would you deal with a short-circuited cable?

Replace the faulty cable if convenient, otherwise isolate it from the circuit, and fit an alternative cable.

How can open-circuits in wiring be located ?

By the use of a test lamp and the vehicle battery. The illustration shows the method. One lead of the test lamp is connected to common "earth", and the other connected

to successive points which if taken in order cannot fail to locate the faulty section. Note also that the open-circuit may be in the earth section.

What should be the rating of the test lamp for open-circuit tests ?

The test lamp should be of a wattage that it passes a current equal to the normal working load or preferably a heavier current up to fuse capacity. A high resistance contact will then reveal itself by local heating and lower brilliance of the test lamp.

How can a break in a cable of an earth return system be located ?

To locate a break in a feed wire, two needle points coupled by a length of wire can be used; the feed wire is pierced by both needles at points about 6 in. apart, moving along the whole length of the wire until the lamp or accessory fed by the wire functions, indicating that the break has been bridged, thus locating the trouble. This method is most suitable on earth or single-pole systems.

What precautions should be taken when testing or re-wiring on the switchboard ?

All disconnected wires should be plainly marked by paper tags so that they can be replaced without any fear of wrong connections being made.

How could you identify and trace wiring in the absence of a wiring diagram ?

A standard colour code is used on the majority of post-war British vehicles (with the exception of the Ford vehicles and some of the Vauxhall range). The main colour denotes the class of circuit, and the tracer shows the individual circuit connection.

What are the main circuit classifications ?

(1) Battery circuit: brown.
(2) Generator circuit: yellow.
(3) Ignition circuit and associated equipment: white.
(4) Auxiliary circuits: green.
(5) Headlamps circuits: blue.
(6) Side- and tail-lamp circuits and associated equipment: red.
(7) Earth circuits: black.

What are the main and tracer colours for individual circuit connections ?

These are as follows:

Main colour	*Tracer*	*Circuit*
Brown		Battery to ammeter, and feeds to battery auxiliary fuse and other units supplied direct from battery.
Brown	Red	Interior light switch to interior light.
Brown	Yellow	Horn relay to wind-tone horns.
Brown	Blue	Control-box terminal (*A*1) to lighting and ignition switch.
Brown	White	Ammeter to control-box terminal (*A*).
Brown	Green	Feeds to units supplied direct from battery, through battery auxiliary fuse.
Brown	Black	Horn-push connection.
Yellow		Generator main terminal to control box and ignition warning light.
Yellow	Green	Generator field terminal to control box.
White		All feeds from ignition switch (unfused), and supply to ignition auxiliary fuse.
White	Red	Starter push to starter solenoid switch.
White	Blue	Choke solenoid switch to solenoid.

White	Green	Petrol reserve valve switch to valve or petrol-pump switch to No. 2 petrol pump.
White	Purple	Petrol-pump switch to No. 1 petrol pump.
White	Black	Ignition coil to distributor.
Green		All feeds through ignition auxiliary fuse. (Units operative only when ignition is switched on.)
Green	Red	Trafficator switch to left-hand trafficator and warning light.
Green	Yellow	Oil-pressure warning light.
Green	White	Trafficator switch to right-hand trafficator and warning light.
Green	Purple	Stop-lamp switch to stop lamp.
Green	Brown	Car-heater rheostat to heater, motor, and warning light. Also reverse-light switch to reverse light.
Green	Black	Fuel gauge to tank unit.
Blue		Main feed from lighting switch to headlamp circuit.
Blue	Red	Dip-switch to headlamp dip filaments.
Blue	White	Dip-switch to headlamp main filaments.
Red		Feeds from lighting switch to side- and tail-lamps and to circuits controlled by side- and tail-lamp switch.
Red	Yellow	Fog-lamp switch to fog lamp.
Red	Blue	Pass-lamp switch to pass lamp.
Red	White	Switches to panel and interior lights.
Red	Black	Boot light to boot-light switch.
Black		All earth wires.
Black	Green	Windscreen-wiper switch to wiper motor. (This is an exception to the general cable identification system.)

Section 12

BODYWORK

After an accident what type of frame damage is likely ?

This will depend largely upon the point of impact:

A direct blow on one of the dumb irons tends to push the side member back.

A glancing blow across the front or rear may affect only the dumb iron.

A blow directly against one of the front wheels may bend the front axle, when fitted, while the rear end of the front spring may be forced into its bracket and buckle the member.

An impact occurring in the centre of the front cross-member may buckle the frame in the region of the dash.

A blow against the rear wheels may cause the axle casing to bend and the wheel arch to be distorted.

Describe a few simple tests for checking frame damage without dismantling the vehicle.

(1) After jacking up the car, test the accuracy of the wheels.
(2) With the vehicle on a level floor, stand some distance in front of the car and sight the roof of the car, the radiator, and the front wings. Twisted frames will usually be shown up by this test.
(3) Examine the fit of the bonnet, the doors and the windscreen.
(4) Check wheel alignment, etc.

What tools are required for repairing damaged bodywork ?

(1) A body jack or stretcher.
(2) A set of sheet-metal working tools, including a

wooden mallet, hide hammer, planishing hammer, bumping hammer, various dollies, files, wrenches, etc.

What is the chief precaution necessary when repairing a dented panel ?

To push it out rather than to hammer it back into shape, because the latter operation spreads the metal.

What methods are adopted in dealing with dents in wings and panels ?

(1) Hot metal shrinkage.
(2) Welding.

What are the most likely causes of a door refusing to shut properly ?

(1) Because the framework surrounding it is not rigid enough.
(2) The hinges are not strong enough.
(3) The holding-down bolts of the body are loose.

What parts of the door lock are likely to set up rattle ?

(1) The bolt, because it has worn the hole in the face-plate, or because it has worn the striking plate.
(2) The top lever, because it has worn where it passed through the bolt and cage of the lock, or because it does not bear properly against the end of the slot plate at the top of the garnish rod.

How is broken glass removed from a door ?

By removing the side fillets, or if these are not used, then through the top of the door.

What is the quickest way to remove glass which has fallen into the door casing ?

Remove the door from its hinges, by knocking up the

hinge pins. The bottom hinge has to be unscrewed if it is close to a wing. Then the broken glass is removed by turning the door upside-down.

What equipment is required for spray-painting on a fairly large scale ?

(1) An air compressor driven from an electric motor or a small petrol engine.
(2) An air receiver or storage tank.
(3) An air purifier.
(4) A suitable length of hose.
(5) A spray gun.
(6) Exhaust fans fitted in the workshop.

What are the common troubles experienced in spray-painting ?

(1) "Orange peel."
(2) "Blushing."
(3) "Pin-holding" or "Bubbling."
(4) "Bleeding."
(6) Body solder.

What are the causes of and remedies for "orange peel" ?

This effect, denoted by a surface resembling that of an orange, is usually caused by incorrect air pressure or lack of consistency in the spraying. Check that air pressure is approximately 55 lb. per square inch. Check that material has been correctly thinned.

What are the causes of and remedies for "blushing" ?

This appears as a white haze over all or part of the surface. The usual cause is an unsuitable thinner or lacquer sprayed under poor conditions such as in a cold, draughty or humid atmosphere. Where "blushing" has occurred, do not attempt to remove the haze but overspray with a suitable thinner.

What are the causes of and remedies for "pin-holding"?

Causes include: use of too rapid-drying thinner; surface drying too rapidly; pockets of air being trapped under the surface; moisture in the air line. Remedies include: use of slower-drying thinner; avoidance of draughts; checking pressure tank for moisture.

What is "bleeding"?

Bleeding may occur when a pale shade is sprayed on to a strongly coloured base such as red or dye blacks, and is caused by the use of various dyes in these colours. It may be eliminated by the use of a lacquer sealer to which aluminium powder has been added.

What troubles may be experienced with body solder?

Body solder is used for filling up imperfections in the metalwork. The most frequent cause of trouble is the use of unsuitable flux which results in the cellulose applied over these spots cracking and flaking off. The remedy is to use a good flux, and to scour the filled-in sections with water-paper before spraying.

Section 13

ENGINE TROUBLE TRACING CHART

REFRACTORY STARTING

Mechanical troubles

- Timing chain slipped.
- Timing-wheel key sheared.
- Magneto drive sheared.
- Pistons broken through.
- Fuel pump out of action.

Electrical troubles

Test with handle with switch at "off".

- Starter switch at fault.
- Starter solenoid at fault.
- Solenoid contacts burnt.
- Battery run down.
- Sulphated battery terminals.
- Brush or commutator trouble in starter.

Engine turns too slowly to induce induction.

- Engine partly seized.
- Starter pinion engaged.
- Sulphated terminals in battery-starter circuit.
- Engine oil too thick.
- Loose connections or burnt solenoid contacts.

Test magneto ignition by laying plugs on engine, connecting up and observing spark.

Magneto ignition

- Switch at "off".
- Switch wire abraded.
- Contact-breaker bush cracked.
- Contact points too wide or too near.
- Sticking rocker arm.
- Distributor tracking.
- Windings or condenser leaking.
- H.T. wires leaking.
- Plug points too wide.
- Drive partially sheared or slipped.
- Condensed moisture in distributor.

REFRACTORY STARTING *(continued)*

Test battery ignition by holding H.T. wire from coil (taking it from centre of distributor) within 9 mm. of cylinder block and pressing starter button. No spark means contact-breaker trouble or coil trouble. If good spark, replace H.T. wire in distributor and try out individual plug wires. If battery down, use starting-handle to reduce battery discharge.

Coil

- —Switch at "off".
- —Battery run down.
- —Battery connections loose.
- —Distributor cover tracking.
- —Rotor worn.
- —Contact-breaker points out of adjustment.
- —Damaged coil.
- —H.T. wires leaking.
- —H.T. wire from coil to distributor.
- —L.T. wires loose on coil.
- —Condenser punctured.
- —Condenser L.T. wire loose.
- —Moisture in distributor.

Listen at intake of carburettor for air movement in induction pipe. Partial silence means little suction.

Carburettor

- —Petrol off or too low in tank.
- —Jets choked.
- —Pipe choked or stopped at outlet.
- —Filter choked.
- —Fuel pump out of action.
- —Air leak.
- —Sediment bulb washer leaking.
- —Carburettor flooding.
- —Choke wire broken.
- —Water in carburettor.
- —Autovac out of order.
- —Choke mechanism seized.
- —Slow-running stop-screw loose.
- —Inlet valve stuck open.

ENGINE RUNS ONLY FOR A SHORT TIME

Partial restriction in fuel supply.
Air leak on suction side of fuel pump.
Carburettor flange distorted or loose, admitting air.
Float needle sticking.
Jet loose.
Water in float chamber or jets.
Filter choked.
Movable obstruction in tank.
Either type of fuel pump faulty.

SPLUTTERING AND MISFIRING

Mechanical trouble
- Timing chain jumped when engine last stopped.
- Broken or bent valve or valves.
- Broken valve spring or cotter.
- Fuel pumps faulty.

Ignition
- Plugs—gap too wide.
- Plugs—sooted up.
- Plugs—cracked insulation.
- Magneto slip-ring dirty, broken brush, cracked holder.
- Magneto distributor brush or brushes.
- Magneto L.T. wire faulty and touching frame intermittently through faulty insulation.
- Cracked distributor.
- Faulty H.T. wires.
- Retarded ignition.
- Seized automatic advance.
- Plug connections wrongly connected.
- Timing slipped.
- Contact points out of adjustment.
- Loose wires anywhere on ignition circuit.
- Faulty coil or condenser, or both.
- Stripped driving gears.

Carburettor
- Carburettor flange distorted.
- Flange washer blown.
- Jets choked.
- Fuel supply inadequate.
- Throttle or choke not set correctly.
- Overstrangled, thus too rich mixture. (Clear by opening throttle wide and turning engine many times.)
- Float punctured.
- Dashpot in S.U. carburettor sticking.

ENGINE STALLS UNDER LOAD

Sooted plugs.
Condenser punctured.
Too rich or too weak mixture.
Main jet choked.
Ignition retarded (denoted by heat also).
Valves not closing through close tappets.
Valve seatings or valve faces gone.

ENGINE WILL NOT RUN SLOWLY

Carburettor

- Autovac drawing fuel through vacuum pipe, owing to worn valves.
- Slow-running device not functioning.
- Slow-running jet (make doubly sure not obstructed).
- Carburettor-flange washer leaking.
- Carburettor flange distorted.
- Induction manifold washer leaking.
- Throttle spindle worn.

Mechanical fault

- Worn valves and guides.
- Throttle control disarranged.
- Accelerator pedal stiff.
- Throttle lever wrongly set.
- Tappets wrongly adjusted (too close) or valve seatings faulty.
- Piston rings fractured (no compression).
- Air leaks anywhere in induction system.

ENGINE NOISES

Piston pin (high pitch).
Big end (medium to low pitch).
Main bearing (deep pitch generally, especially near flywheel).
Crankshaft end play (like hammer blows).
Camshaft (medium, but half-time of engine generally—not always).
Dynamo brushes (squeak until warm enough for grease to lubricate commutator).
Fan belt (timed flap or light knock at times).
Piston slap (when engine cold; goes off as alloy piston expands).

INDEX

A

A.C. fuel pump, 36
Accessories, 128
Accidents, faults caused by, 17
Alignment of headlamps, 125
Automatic cut-out, 75
  timing control, 57

B

"Backfires" in silencer, 6
Backlash in steering gear, 118
"Banging" in silencer, 21
Batteries, 62
Battery charging, 69
Bevel gears, 96
Bodywork, 142
Borg and Beck clutches, 87
Brake:
  "chatter", 102
  pedal, 103
  shoes, 104
    adjustment, 105
    relining, 102
  squeak, 103
  testing, 99
Brakes, Lockheed hydraulic, 107
Brush gear, 72
Burnt contacts, 56

C

Cable, location of break in, 139
Camber, 113
Camshaft, 102
Carburettor piston, sticking, 23
Carburettors, 19
Cardan joint, 97
Caster angle, 113
Charging battery, 69
"Chatter", brake, 102
Circuit for starter motors, 78
  wiring, colour code, 140
Clock, electric, 134
Clutch:
  drag, 87
  judder, 89
  pedal, 93
  rattle, 91
  spin, 87
Clutches, 85
Coil ignition equipment, servicing, 49
Cold-starting difficulties, 2
Compression pressure of engine, 10
Condenser, 58
Connecting rods, 15
Contact breaker gap, 46
Contacts, burnt, 56
Cooling, 42
  system, cleaning the, 43
Cupped tyres, 120
Cut-out, 75
"Cycling" (battery charging), 69
Cylinder bore, 11

D

Decarbonising, 5, 8
Dipping reflector, 127
Distributor:
  cover, 55
  rotor, 56
  wear, 57
Doors, failure to shut, 143
Dynamos, 69

E

Electric clock, 134
  horns, 128
Engine:
  compression, pressure, 10
  "knock", 16
  noises, 149
  stoppage, 3
  trouble-tracing chart, 146
Equipment for engine testing, 1

F

Fan belt adjustment, 45
Fierceness of clutch, 88
Flooding of carburettors, 28
Frame damage, 142
Front wheel shimmy, 122
Frost damage, 18
Fuel, lack of, 38
  pumps, 36
Fused wiring circuit, 136

G

Gearboxes, 94
Gearbox oil leaks, 96
Gear noise, 94
Grinding in valves, 8

H

Headlamp alignment, 125
  dipping circuit, 127
High-frequency horn, 130
  -rate discharge test for batteries, 65
  -tension cables, 51
Hooke's joint, 97
Horns, 128
Hot-starting difficulties, 2
Hydraulic brakes, 107
Hydrometer battery test, 63

I

Idling device, 21
Ignition, 49
  coil, 59
  test, 49
  warning lamp, 71
Insulators, split, 55

K

King-pin inclination, 113
"Knocking", 4, 16, 31
"Knock", main bearing, 16

L

Lamp, failure to light, 126
  ignition warning, 71
Leaks in radiators, 42
Legal requirements, 128
Lockheed hydraulic brakes, 107
Lubrication, 46

M

Magnetos, 59, 60
Main bearing knock, 16
Mechanical test, 3
Misfiring, 148
Motors, starter, 78
  windscreen wiper, 132

N

"No charge", 72
Noise:
  engine, 149
  fuel pump, 38, 49
  gearbox, 94
  valve rocker, 9

O

Oil consumption, excessive, 47
  leaks, 47
    in gearbox, 96
  pressure, incorrect, 46
"Oiling up" of spark plugs, 55
"Open-circuit" in wiring system, 138
Overheating of engine, 43, 45

P

Petrol consumption, 21, 33
  supply test, 3
  wastage, 21
"Pinking", 5
Piston:
  faults in, 14
  rings, 13
  "slap", 1
Plain-film block-type radiator, repairing a, 43
Propeller shaft, 97
  end play, 97
Pumps, water, 44

R

Radiator, 42
  hoses, 44
  leaks, 42
Rattle in door locks, 143
Rear axle, 97
Refractory starting, 146
Regulator unit, 72
Relining brake shoes, 105
Repairs to bodywork, 142

S

S.U. carburettors, 23
  electric pump, 40
Scuffed tyres, 120
Shock-absorber faults, 114
Short-circuit in wiring system, 135
"Slap", piston, 15
Slipping clutch, 89
Slow running, 149
Solex carburettors, 27
"Sooting up" of spark plugs, 54
Spark plugs: 51
  detecting faulty, 52
  "oiling up", 55
  "sooting up", 54
Spray-painting, 144
Starter motors: 78
    loss of power, 79
    seizing up, 81
Starting troubles, 2
Steering, 113
  gear wear, 118
  wobble, 118
Stopping distance, 101
Stromberg carburettors, 31
Sulphation, 67

T

Tappet clearances, 5, 33
Tecalemit DL- and DR-type pumps, 38

Tests:
batteries, 63
brakes, 99
buckled wheels, 119
carburation, 19
compression pressure, 10
equipment for, 1
ignition, 49
petrol supply mechanical failure 3
transmission fault, 85
Thermostat, 13, 44
Throttle-bias, 22
Toe-in, 113
Transmission faults, 85
Tyres, 120

V

Vacuum unit, 57
Valve rocker noise, 9
troubles, 6
Valves,
burnt, 7
pitted, 7
Viscosity of oil, 46
Voltmeter, 137
Vulcanising, 124

W

Wandering, 121
Water circulation, 44
level in radiator, 44
loss in cooling system, 45
pumps, 44
Wear:
cylinder, 12
steering gear, 117
Wheel bounce, 114
Wheels, buckled, 119
Window, repair of broken, 144
Windscreen wiper motors, 132
wipers, 131
Wiring, colour code for, 140
equipment, 125
faults, 135

Z

Zenith carburettors, 33

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